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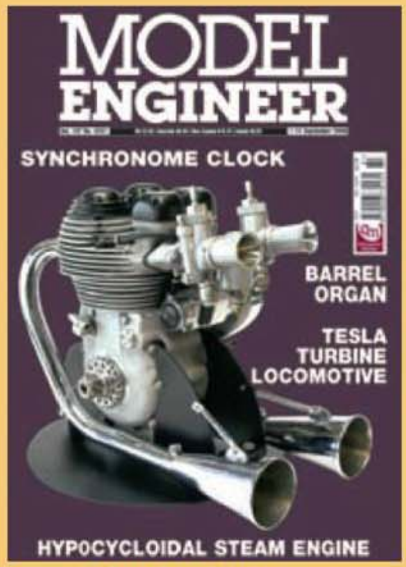

On the cover ...

Seen and heard recently at the Guildford Rally, the stunning model of the twin cylinder Matchless motor cycle engine built by Bill Connor. This engine was also awarded a gold medal and the Edgar Westbury Memorial Trophy at the last Model Engineer Exhibition. At Guildford visitors could see that not only is it a fine display model, it runs as well as it looks. A report on the Guildford Rally will appear in the next issue

(Photograph by Malcolm Stride)

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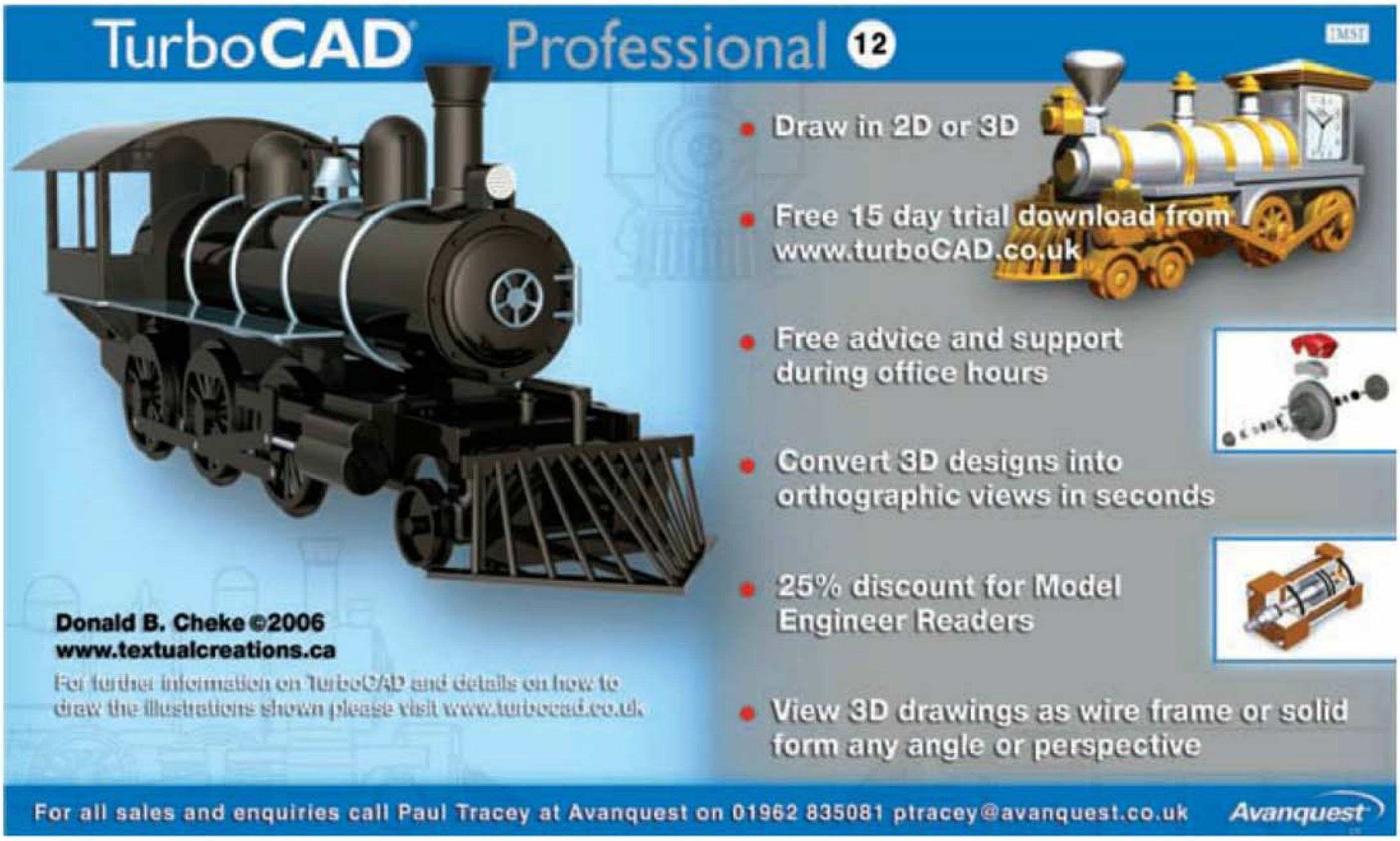

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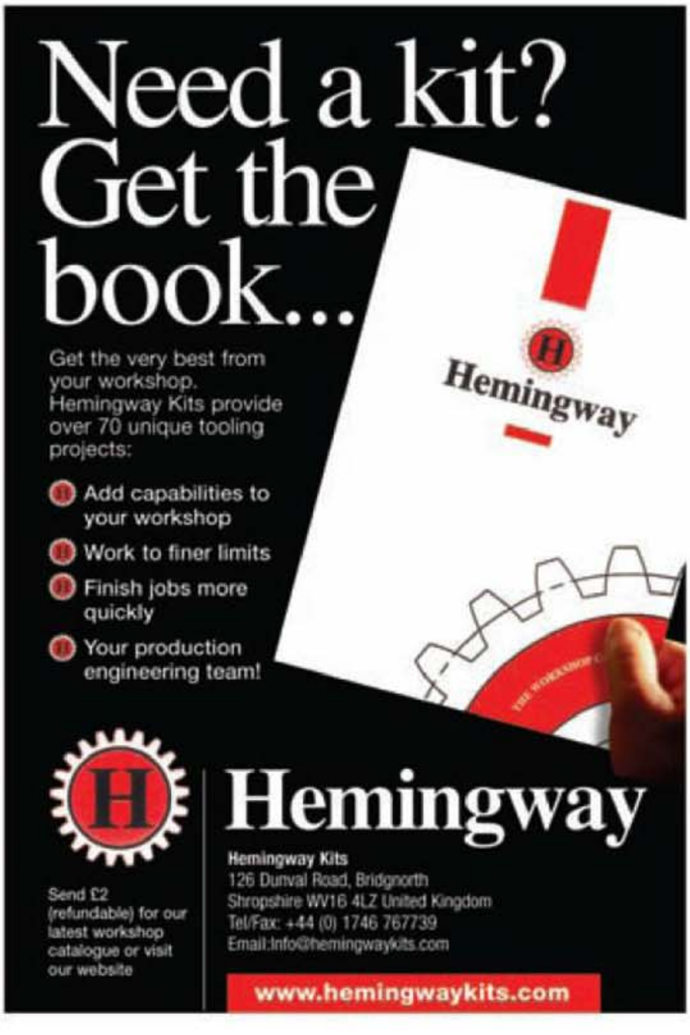

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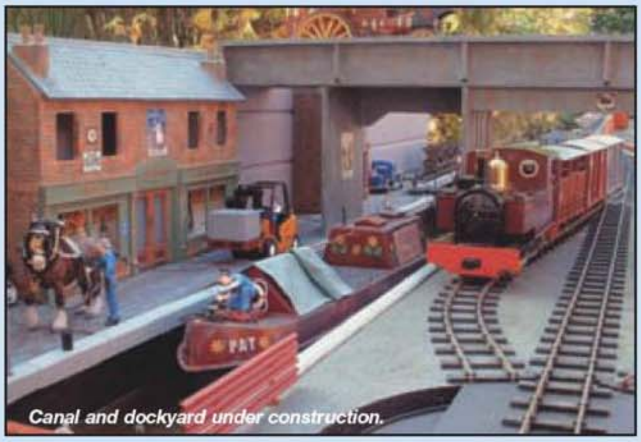
SMOKE RINGS
With the Editors

Progress at Stranraer

Ray McMahon has sent us a couple of photos showing how far his garden railway has progressed. Our first picture shows his 24-foot long model of the Forth Bridge, and the second, a canal and dockyard scene that is under construction. The layout is for 32mm narrow gauge, with live steam locomotives, radio controlled. We look forward to seeing it all finished later in the year.

Completed Forth Bridge.



Canal and dockyard under construction.

Many happy returns Monty

Recently, we published the 90th *Letter to a Grandson* from M. J. H. (Monty) Ellis. A week or two later Monty celebrated his 90th birthday.

When he is not writing his popular column for *Model Engineer*, Monty is a popular chap in his home town of Rangeworthy, Bristol. There he practices one of his other talents as organist at Holy Trinity Church, where he has been playing for the past 25 years.

This has made him very popular with the ladies of the parish, and he received not one, but, five cakes on his birthday. Monty tells us that since his wife sadly died a couple of years ago, the ladies have kept him supplied with his Sunday lunches, too.

The local paper, the *Dursley Gazette*, also interviewed him on his birthday, and we are grateful to the editor for our photograph of Monty on his birthday.

The paper also reported his recipe for long life: "*Always say a good word to somebody. It doesn't cost anything and there is great satisfaction in doing good for other people.*"

Grandfather Ellis.

Curly Bowl

A final reminder that the LBSC Memorial Bowl takes place this Sunday, September 3, at Roker Park, Sunderland. Get along there with your Curly models, and enjoy a memorable day at this enjoyable event. Contact Albert Stephenson from the City of Sunderland Model Engineering Society on 01429 299649.

Swansea sessions

Gorseinon College tells us that its popular model engineer classes start again this month. The Model Engineer's Club meets on Tuesday evenings 7.00 – 9.00pm, and provides a good facility for this enthusiastic group working on a wide variety of projects. Full workshop facilities, with help where needed, are available. The college also offers a 'Welding for Beginners' course on Wednesday evenings. Beginners can learn how to weld safely using gas and arc equipment. It is suitable for hobbyists and those who wish to go for a BTEC Award at Level 1.

For both courses, call 01792 893054 or 890754.

Letters via email

Letters to the editor via email, including those for publication in Post Bag, are most welcome. The address is:

david.carpenter@encanta.co.uk

However, please include your postal address and email address at the end of each letter. We will not publish these details, but it will enable us to forward post and emails, sent via this office, destined for our contributors and correspondents.

CHUCK, the MUDDLE ENGINEER — **by B. TERRY ASPIN**

POST BAG

College engineering gear cutter

SIRS, - I would be pleased to learn of details of any College Engineering Gear Cutting Machine construction 'club' that may exist. You have printed photographs over the past years of various examples and I have seen machines at several venues and I now wonder if there is such a group.

Keep up your good work in *M.E.*! I look forward regularly to receiving my latest copy in the post.
Brian Warner, Buckinghamshire.

Sifbronze and boilers

SIRS, - I have read Peter Rich's articles about Boiler Making with interest. Like him I am familiar with the Australian (AMBSC) codes and think that on the whole they give a reasonable and practical way of making an acceptable boiler. I do have a few reservations about them however.

The use of palm stays is detailed in the codes and I think, deserves more publicity as a useful technique in some cases. I think Mr. Rich went rather overboard in using so many of them between the firebox crown and the sides of the outer wrapper and in an arrangement which appeared to be impossible to assemble. I was thinking that it was more than a coincidence that it appeared in the first issue in April but in a later part he described a method of assembly which seemed possible. I will just say that I wouldn't attempt to use palm stays in that situation,

I note that Mr. Rich advocates the use of Sifbronze to braze some of the boiler joints, I presume that he uses Sifbronze No. 1 alloy which is the common one for brazing copper or steel. I do not consider this to be a suitable material for use in a boiler. Comments have been made at NAME meetings that it is subject to corrosion when in prolonged contact with water. Its typical percentage composition is 60% Copper, 0.3 Silicon and the balance Zinc i.e. it seems to be a brass! The other brazing alloys using the Sifbronze name which I have found also have about 40% Zinc so I doubt if they are suitable either. It is generally accepted nowadays that brass should not be used in boilers in contact with steam or water. The use of brass in such situations is actually prohibited by the AMBSC codes. I would be interested to see any justification Mr. Rich or anyone else could produce for the use of Sifbronze in boilers. I would not be convinced by claims of numerous boilers being so made, unless there was also an explanation of how the absence of internal corrosion was verified and consideration given to the effect of differing qualities of boiler feed water.

With reference to the query from John Pitkin to Nemett in I/C Topics (*M.E.* 4275, 9 June 2006) concerning the conversion of the stochiometric ratio of 14.7 to 1 into the volumetric ratio of air to petrol. All that is required is the density of air and petrol which my venerable copy of Kaye and Laby 1936 gives as 1.2928 grams/litre for air at 0deg. C and 760mm of mercury and a density of 0.68 - 0.72 for petrol. This gives a volumetric ratio of air to petrol of about 8000 to 1.
F. A. J. Collin, Oldham.

With regard to that last part of Mr. Collin's letter, I have had a lot of letters regarding stoichiometric ratio and will be putting more information with comments from those letters in a future issue. I have to admit that the density calculation did not occur to me at the time (editorial senior moment!) but am not convinced that things are that simple because the ratio has to be correct under the compression and temperature conditions in the cylinder not at atmospheric pressure.

In the mean time I thank all those who have sent in information and comments – Nemett.

Aeronautical matters

SIRS, - With the Editor's indulgence I would like to make a few additional comments relating to aeronautical matters raised in *Post Bag* over the past few months.

Mr. Roy Simmons (*M.E.* 4274, 26 May 2006) mentions the radial-engined Lancaster B Mk. II being equipped with the Bristol *Hercules* Mk. VI engine; however, out of a total of 300 Lancasters of this mark, produced exclusively by Sir. W. O. Armstrong Whitworth Limited, at Coventry, from September 1942, only the initial 27 machines had the *Hercules* Mk. VI engine, all the remainder had the *Hercules* Mk. XVI. I would like to know, however, and perhaps Mr. Simmons may be able to help me here, if the oil pressure relief valves, situated in the cylinder heads of the *Hercules*, to relieve accumulated oil at the junk head sleeve joint, were located only in those cylinders at or near the bottom of the engine, or were they distributed throughout the entire 14 cylinders?

Regarding Mr. Simmons' reference to the lapsed Whittle Jet Engine Patent of 1930, this document came up for renewal in January, 1935. John Golley relates in his book, *Whittle, The True Story* that at the time Whittle took a conscious decision not to renew his patent. No one had come forward to assist him in his enterprise, and he also realised, perhaps more than anyone else, the almost insuperable difficulties that would have to be overcome to exploit the practical application of the patent. Whittle also had a young family to support, and there were more pressing needs for his limited resources. The Contracts Directorate at the Air Ministry informed Whittle, in early January 1935, of the impending expiry date of the patent, but made it quite clear that the £5 renewal fee would not be forthcoming from the official purse!

This niggardly and extremely short-sighted piece of officialdom should be contrasted with the almost unbelievable ineptitude of the British Government, over a decade later, when it sanctioned the supply of 25 Rolls-Royce *Nene* and 30 *Derwent* Jet Engines to the Soviet Union, in September 1946, In one gigantic leap the Soviets cheaply acquired the world's most advanced gas turbine technology, which they proceeded to marry to captured wartime German airframe developments. The resultant outcome was the MiG-15 fighter, which came as a tremendous shock to the West at the time of the Korean War. Britain's frontline fighter, the Gloster Meteor, was hopelessly outclassed in combat with the MiG-15. This situation was only redressed by the United States producing the North American F-86 Sabre from drawing board to prototype, within 100 days!
John Willock, Warwickshire.

Brooklands Miniature Railway

SIRS, - I am writing a book about the Brooklands Miniature Railway at Worthing, West Sussex as I have many childhood memories of this railway. I wonder if you could add this letter to your magazine to see if there are any readers out there who may also have memories of the railway or possibly any photographs they may wish to add. The brief history below may be of some help.

The $9^1/2$in. gauge railway was constructed in 1965 and operated an American Clipper engine called *Lake Shore*. A $6^1/2$hp petrol locomotive was also operated from this time until 1967 when the stock was replaced for $10^1/2$in. gauge track and a Severn Lamb Ltd. locomotive and carriages.

This locomotive survived at Brooklands until the beginning of this year when it was sold to Joe Nemeth of the Berkeley Light Railway in Gloucestershire. The carriages are still being used along with the locomotive from Hotham Park, Bognor Regis, West Sussex. The railway is open daily and still does very well with the visitors.

I would greatly appreciate your help on this matter.
Graham Lelliott, Sussex.

More on global warming

SIRS, - I wish add my two pence worth to the global warming subject. I must agree with the commentary of Mr. N. M. Macnaughtan (*M.E.* 4273, 12 May 2006) on the effects of carbon dioxide (CO_2) with its ever increasing volume and its harmful effects on the earth's atmosphere. Whether or not this gas has become more prolific through human endeavours during the industrial age is not a contentious matter, we have undoubtedly played a major role in the excessive quantity of this gas presently at large in our environment, which is the only environment we have.

In addressing a Mr. Robinson's response to a previous letter (*M.E.* 4267, 17 February 2006) Mr. Macnaughtan briefly mentioned an even more potent greenhouse gas, methane (CH_4), which he did not elaborate on. This is both a fossil and currently carbon-based gas. If found in a coal mine it is definitely classified as fossilised, on the other hand when generated by present day activities it is definitely a current feature in the make up of our atmospheric gases.

Methane currently produced by natural means, is an involuntary function of animal and human behaviour; it's emitted by flatulence and faeces, as the result of microbial action.

Methane was widely used as an alternate vehicular fuel in the 1939/45 conflict. I can remember seeing internal combustion engine operated vehicles driving around with a large gas bag secured to them. This denotes that methane has both a detrimental and beneficial aspect to it. Mr. Macnaughtan only referred to the negative factor of its nature.

Carbon dioxide is sequestered in the oceans, which act as a natural sink for it. It's confined at a depth where it is consumed by microbial components and then excreted as methane. Due to the temperature and pressure it is turned to a liquid and then freezes and converts to methanol hydrate. This source is proving difficult to recover. When feasible to tap into this resource, we will have access to a commodity, from this oceanic source alone; that is in excess of all known fossil carboniferous reserves.

Methane is obviously obtainable cheaply and in renewable amounts from the agricultural sector, municipal sewage and rubbish dumps, which reek of the stuff. In effect we have a naturally sustainable fuel supply at our disposal that is obtainable worldwide, in respect universal and one that cannot be controlled by a cartel.

What methane transforms into when combusted I don't know, most likely carbon and water No doubt other readers will comment on this assumption if incorrect.

We already have a controversial dialogue underway. With the widely varied interests of the Model Engineering fraternity this topic will most likely be considerably expanded before it's all over.

I am looking forward to reading other points of view and further correspondence on this matter.

E. (Ted) Dennis, Vancouver Island, Canada.

Hunslett steaming

SIRS, - Some years back (nearly 10) I built a 5in. gauge Hunslet to Don Young's design. I made quite a few modifications using side tanks instead of a saddle tank and beefed up various bits and pieces otherwise it is to his design.

I enjoyed building and running it but I found that the water consumption was huge. According to drawings and his article at the time I made the cylinder bores $1^3/4$in. diameter. He said in his article *"I like big cylinder bores"* which is okay if you can feed them. I came to the conclusion running on a club track that the lack of grate area was the problem (it is approximately 6 x 3in.) Having then gone through a small book with various Hunslet locomotives it appeared that the bores should have been $1^1/2$ inches.

After some calculations I made up my mind to sleeve the cylinders. I did not have to take the cylinders off the locomotive. I made up a try piece, machined a large piece of cast iron inside and outside and made the bore $1^7/16$ inches. The sleeves fitted fine and I inserted a grub screw through the existing castings having milled out the ports first.

I have just run the locomotive for the first time and the difference is most noticeable especially not having to pour water in constantly. More important is that I can maintain pressure which I could not do before.

I would like to know if other owners of 5in. gauge Hunslets have encountered the same problem.

P. H. Lewis, Norfolk.

Asian machine tools

SIRS, - The debate about machine tools from Asia has been very interesting but I have to come down on the European, if not solely UK side, simply because I would not have the competence to make the recommended adjustments and minor modifications to an imported machine. Further, I admit an illogical prejudice in favour of domestic products, possibly due to growing up well pre-war - the globe was red nearly all over, and British Made was very significant!

I think the question of origin is not confined to our major capital purchases. I frequently wonder if the small items are as good as the indigenous items we used to buy, such as drills, end mills, taps etc. I have three boxed sets of Dormer drills, Imperial, Number and Metric. Basically they have lasted for years but there are sometimes casualties among the smaller sizes as used for BA tapping. They lose their keenness and I occasionally break one. My mail order replacements are bright and shiny and in my opinion don't seem to last like the black ones. The latter may be dearer but I would much prefer to pay more and maintain my sets with like items.

I realise drills can be sharpened - not by me they can't! Now I need one or two end mills and slot drills and I want the right items. Any recommendations?

Dennis Randall, Oxfordshire.

Gauge glass seals and other things

SIRS, - May I be permitted a few words in *Post Bag* in answer to Neville Evans article (*M.E.* 4274, 26 May 2006) with reference to gauge glass seals. The seals are not my idea but were recommended in an *M.E.* editorial a few years ago and which I believe had been drawn to the then Editor's attention by a gentleman in Brazil.

The seals, I omitted to mention, are formed by the use of Dow Corning's '754' formula, a liquid rubberised solution which rapidly cures to solid after application. With the use of this solution there is no need to compress the gauge glass with the top cap as the boiler pressure will force the seal into any joint around the glass provided reasonable clearances have been provided.

By mistake I omitted to mention this alternative to O-rings in my short article (*M.E.* 4269, 17 March 2006) and I was not in any way trying to say that his use of them was not suitable for the purpose. Indeed I also have used O-rings for this purpose in the past, but thought that I was simply recommending a seal which allows me to construct a water gauge much closer to scale than hitherto. My article was prompted by two correspondents who had previously written in *Post Bag*.

In the same article Neville Evans has stated that the chassis of a County is identical to that of a Modified Hall apart from the diameter of the coupled wheels.

Currently I am responsible for all of the new design work to convert the full size Modified Hall No. 7927 *Willington Hall* into the new County class No. 1014 *County of Glamorgan* on behalf of the Great Western Society. I have been working on this project for the past four years, work which has involved me in a great deal of research into both classes from which I can very definitely state that their chassis were not identical. There are a lot of differences between the two classes, other than their boilers and the different size driving wheels, indeed so much so that it has just cost the Great Western Society over £25,000 to alter the Hall chassis to accommodate my alteration design work to turn it into a County chassis.

These differences start at the very front of the engine with the buffer beam height in relation to the rails. They are continued through the bogie where alterations have to be made to accommodate the raised height of the main frame required to suit the larger driving wheels of the County. The alterations continue with the valve gear where re-positioning of the rocking lever bracket has to be carried out together with a lengthening of the inside valve rod and the outside rocking arm to increase the valve travel. This also means that new valve liners with larger ports and new piston valve heads will have to be provided to suit the longer valve travel.

Further alterations have to be made to the intermediate frame stretcher in front of the firebox and also to the design of the rear drag box and buffing plate. In addition to this connecting and coupling rods with larger bearings have to be provided to absorb the power from the higher boiler pressure.

Some of the differences between the two classes can be easily seen by comparison with photographs probably the most obvious of which is the single elongated wheel splashers on the County whereas the Hall has separate splashers for each wheel. What is not easily detected is the alteration required at the rear of the cab roof on the County, due to its increased width over other GW engines, in order to keep it within the loading gauge. The elongated wheel splashers can be seen in the same issue in my drawing of my 5in. gauge design for the County. Here I have outlined some of the differences between the two classes but there were a number of others which I feel are too numerous to go into at this stage.

Pete Rich, Newport.

Wimpeys

SIRS, - My letter in a recent issue was simply to mention the title most commonly used in the RAF for the Wellington mine clearing aircraft i.e. *"Wedding Ring Wimpeys"* and also to add some information on the problems found with Bristol sleeve valve engines after high running hours. However, Mr. Bourne and Mr. Shilling dispute the verity of some of my statements, I would of course defer to those with a more profound knowledge of these subjects, and with practical experience in the operation of aircraft of the WW2 period. So perhaps it would be pertinent for them both to provide information as to their own expertise in this field of aviation.

For myself, I joined the RAF very early in 1940 and qualified as an Airframe Fitter, part of the course being on Spitfires, and then engaged on repairing battle and accident damage to both Hurricanes and Hampden bombers. For ease and speed of repair, fabric covered metal frame aircraft win hands down, and removing the 52 x 2BA bolts of the Spitfire tail section to gain access to the fuselage interior was not for the faint-hearted. I was accepted for

Model 'wedding ring' Wimpey at Brooklands Museum

Pilot training and spent most of 1941 engaged in ferrying Hurricanes to Malta. Nearly two years was then spent as a SFTS multi-engine flying instructor in Southern Rhodesia and on returning to the UK in late 1944 I joined the Tiger Force Group that was being assembled for operations with Lincoln bombers against Japan. One or two points that I can clarify, an obvious Wellington derivative was parked on our base in England, it was fitted with a pressure cabin and we were told on what seemed the best of authority that there were problems with this, that it was designed to fly at 50,000ft. and was to be called the Warwick. As regards Wellingtons struggling to reach 30,000ft., with the two-speed supercharger *Hercules* engines, there was absolutely no problem, this was possibly the incentive to develop the 50,000ft. aircraft. It was very cold at these heights, and with lack of cabin heating, the thick Kapok lined inner suits issued were essential.

For its size, the Wellington was a very agile aircraft, the wings spanning not far short of 100ft. and which would wave around at times in flight. Spud Boorer, one time Principal Assistant to Barnes Wallis, was kind enough to show me round the remains of the Vickers Brooklands works, said that the prototype had broken up in mid air. Had I known I would have been more gentle with them. Incidentally, the Hurricanes, mostly Type 2As, that I helped to repair and also fly, could reach considerable heights, the official Service Ceiling being given as 36,500 feet.

Mr. Shilling is correct about the pre-flight drills carried out by aircrews, in manually turning propellers to fully revolve the engines, to check for hydraulic locking. My suspicion is that ground crews, perhaps in a hurry with inspections or moving the aircraft were to blame for the damage caused in most cases.

My wartime copy of *Janes* stated that the Westland Whirlwind was fitted with RR Goshawk steam cooled engines, *Janes* were rarely wrong. However, the Whirlwinds were regarded as underpowered when fitted with Peregrine engines, which were stated as being faulty, the Goshawks 3 or B41 were more powerful at almost 700hp and possibly available. It could be that it was such a proposal picked up by *Janes* at such uncertain times.

The1050hp *Merlin* C would have been ideal, but no doubt in short supply. With these and the four 20mm cannon armament, this aircraft would have been a great asset; the rather high landing speed could have been a problem for newly qualified pilots.

Regarding the *Kestrel* engines supplied to the Germans prior to WW2, no doubt they could have obtained them through other sources, but deplorable to have had official sanction from the Air Ministry, perhaps this was part of the political appeasement policy. The Kestrels were not only produced as the 12-cylinder inline units, but also as a 60deg. V and even steam-cooled versions.

If a recent TV documentary is to be believed, Whittle offered his patents to the air ministry before the normal publication, but they were declined by the official that he met, who had his own ideas for jet propulsion.

A year or so after, German patents on the subject appeared in *Flight* and *The Aeroplane* magazines nearly every week, and about this time an Italian jet aircraft was flown. The fuselage a large hollow tube, with an engine and propeller inside, the pilot perched on top, rather crude but I believe they were the first, unless anyone knows differently.

The tired old chestnut of Wellington fuselages being stretched when glider towing trials took place at Ringway, is aired once again, if this did actually take place, did the manual control runs to the rudder and elevators also do so by the same extent?

Cyril Cannell, Isle of Man.

De-coking sleeve valve engines

SIRS, - In reply to Ted Wale's letter (*M.E.* 4277, 7 July 2006), the advice not to de-coke a sleeve valve engine came from several (when I was told over 45 years ago) OLD* motor mechanics. I have first hand experience of two engines – a 'Blackburn' twin cylinder and a four cylinder the name of which escapes me; the owners had de-coked and polished everything on restoration. The result was virtually no compression; it would appear that the coke takes up the clearances from wear – two of them – piston/cylinder sleeve and cylinder sleeve/barrel or block. When the engine is new the clearances are such that a reasonable compression was available – remember that these were very low by our present day standards. Casting my mind back 45 odd years I think that the compression ratio of the above two engines was in the order of $4^1/2$ to 5:1. The clearances without the coke allow large oil flows – despite the rings - and these engines were sometimes prone to what was called 'pumping' between the sleeve and the barrel.

As to the sleeve valve aero engines I remember discussing these with an ex-RAF engine fitter I worked with circa 1959. He had mostly worked on radial engines (of vast size and number of cylinders) and I have a feeling that new sleeves/barrels and pistons were fitted on a general overhaul so the problem never occurred. If these engines were 'blown' then they also were probably around 5:1 compression ratio. Incidentally the *Sabre* wasn't the most powerful piston aero engine that was the *Crecy* by 'Ricardo' which never flew. This was an 'X' formation 48 cylinder sleeve valve blown two stroke of terrifying performance. Ricardo was the expert on sleeve valves whose work dissuaded the Bristol engines from throwing sleeves – but was never acknowledged.

I didn't mention sleeve valve radial aero engines in the previous letter because they are made from rather exotic alloys and with very tight working tolerances, also they typically have a vastly longer development to reach reliability and high output than the engine the original correspondent was referring to.

If designing a sleeve valve engine always make it with a semi-rotary reciprocating sleeve in order to ensure proper lubrication of the sleeve/barrel area. Plain reciprocating sleeves whilst easier to make, all suffer from 'patchy' lubrication and seizure. I think the amount of rotation wasn't great, something like 10 – 20deg. but sufficient to spread the oil right round the sleeve (and make positioning of the ports interesting!). There is a limit to the amount of oil that can be used because of the ports in the sleeve – too much and it poured through the ports. As I have said before, these were 'smoky' engines even when made to 'aero' standards. Their advantage was they were very good at running at a constant speed which is why with the cost of production they were never really successful in an automotive world.

*They were about my present age but they seemed/were old, scarred and wise in the ways of engines!

Peter King, New Zealand.

Propane fired crucible furnace

SIRS, - I wonder if anybody in *M.E.* land could help me? Back in December 1993 (*M.E.* issues 3958 and 3965) a gentleman named A. F. Bond wrote an article on constructing a small crucible furnace. It is just the thing for a back garden foundry and it uses propane gas. I need an injector for this or information on how to make one as IMI Ltd. the Amal division which made the injector closed down about 10 years ago and the company said sorry can't help.

So can anybody help please?

Ken Surrey, Berkshire.

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TESLA STEAM TURBINE LOCOMOTIVE

Werner Jeggli describes a somewhat different drive for the gauge 1 Intercity Train *Der Mathematiker*.

Fifteen years ago, I had a dream. I saw a sleek high speed tilting type train, headed by a steam driven engine. It used its exhaust steam condensate as boiler feed water to make sure the locomotive would not run out of steam between cities. Oh – of course, the train was not full-size. It ran on gauge 1 track. You see – even my dreams tend sometimes to take the real world into account!

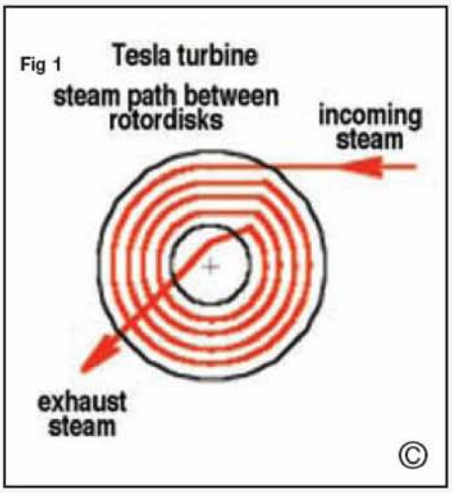
Ever since that time I've been busily working to make this dream come true. Eleven years later, the task was achieved. In November 2001, the train consisting of the locomotive, the condensing tender and five coaches was christened with the name of *Der Mathematiker*. What does she look like? **Photograph 1** shows the ensemble, in good company, at a meeting in the southern part of Switzerland.

A Butane-fired boiler powers the locomotive. In 2001, the steam was feeding two double-acting, oscillating cylinders located in the rear-motorised truck. The tender contains a condenser and four battery-driven cooling fans. With this initial drive, the engine was capable of hauling the five coaches at 200kph scale speed (1/32).

In the following years my efforts were directed toward replacing the oscillating cylinders by a steam turbine. To my knowledge, no attempt at building such a drive had been very successful in the past. It took a lot of time and determination, but in autumn 2003 *Der Mathematiker* was running impulse turbine driven via a reversible gear train. The only disadvantage was the reduced cruising speed of 170kph. This meant, that the turbine power output was somewhat on the low side.

The next step was the replacement of the above turbine by a better drive. It is this project I would like to present in the following pages. It is split into two sections. The first part describes the turbine in general, the second shows constructional details which should allow a model engineer to build a similar engine with a good chance of success.

Fig 1



The turbine

It might be helpful at this stage to provide some background information. Nicola Tesla (1856–1943) is mainly known for his inventions in the field of electricity. But he was also active in other domains. In 1920, he patented a simple machine which could be used as pump or turbine for different media. The machine operates on the principle of boundary layer drag between gases/fluids and solid materials. The invention did not become widespread mainly because its reputation of low efficiency.

What did this mean for my project? The oscillating cylinders and the impulse turbine themselves had an extremely poor efficiency (below 0.1%). The new approach could not be much worse. On the other hand, the Tesla turbine would be able to operate in both directions, would even able to brake dynamically – ideal for train operation! I decided to give it a try.

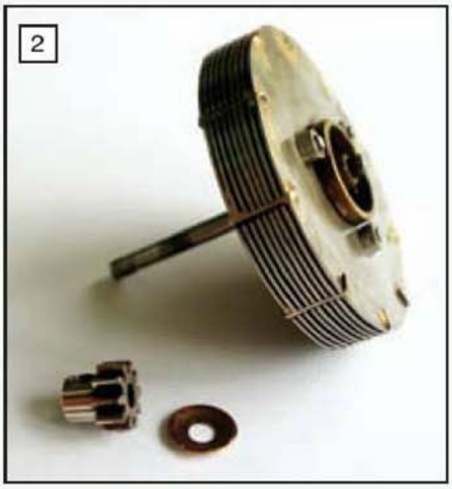
Tesla's invention works as follows: A steam jet coming out of a fine slot hits tangentially a rotor disc stack. The jet is be deflected between the discs by the turbine housing and makes a 360deg. turn. The 'old' steam will then hit the 'new' incoming steam and thus be forced toward the centre of the disks. This cycle repeats itself until the steam can leave the rotor via the centre openings. A real 'tornado' will establish itself between the individual discs, which makes them turn rotate. Direction of rotation can be changed by directing the jet entry in the opposite direction (see **fig 1**).

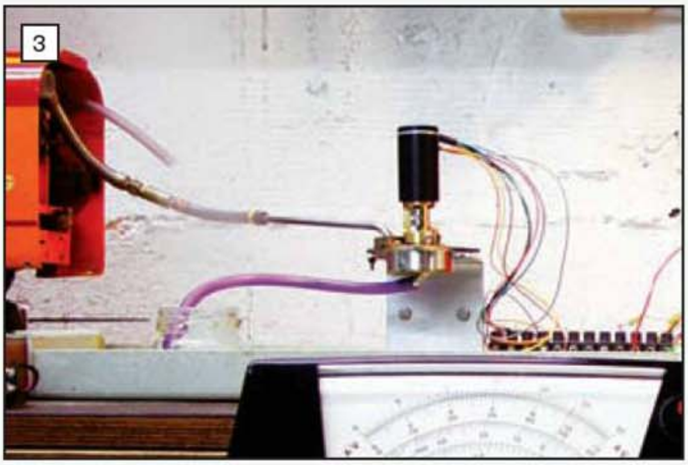
Starting with an experimental rotor having a stack of 30mm dia. aluminium alloy discs, 0.5mm wide and spaced 0.5mm I attempted to investigate my chances of success. On the test bank I could measure the shaft power output via a mini generator and read the speed on a digital display. The results were encouraging. With my existing boiler capacity I could expect a power output of 1 to 2 Watts at around 40,000rpm. On the negative side I experienced fast corrosion of the disc rims, leading to contact with the casing and a corresponding dramatic loss of speed. It seemed also that condensation within the turbine hampered speed pick up of the rotor quite heavily. It was obvious, both of these components had to be made out of corrosion resistant and thermally, bad-conducting stainless steel.

The description which follows presents the results of the sometimes laborious, and slow, development work and also provides some background information on how the solution was arrived at.

The heart of the turbine – of course – is the rotor. The shaft, the nine stainless steel discs and the exhaust steam opening in the centre can be seen (**photo 2**).

After completion of the turbine, runs on the test bank were required to determine the power output available at different rotor rpm. **Photograph 3** shows, on the left, the rear part of the locomotive and the steam supply to the turbine. In the middle is the turbine coupled to a brushless DC motor (used as a three-phase





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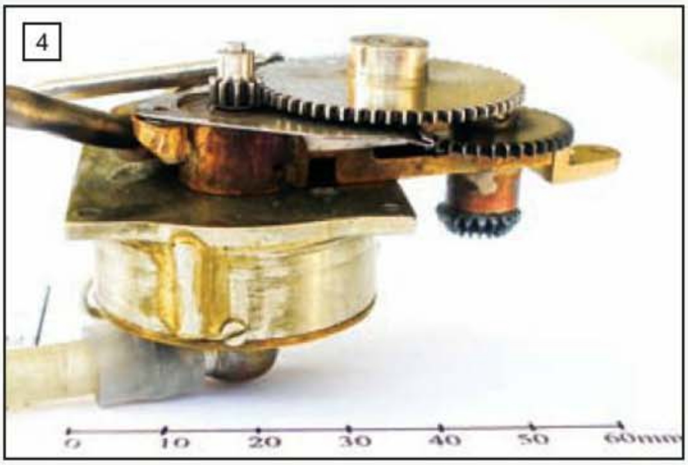

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generator). Below, the violet steam exhaust hose leads into a jar and the DC voltmeter. Not shown in the picture is the speed indicator (run off the hall sensors inside the DC motor) the bridge rectifier block, the milli-Amp meter and the potentiometer box to vary the load.

The following results were arrived at:

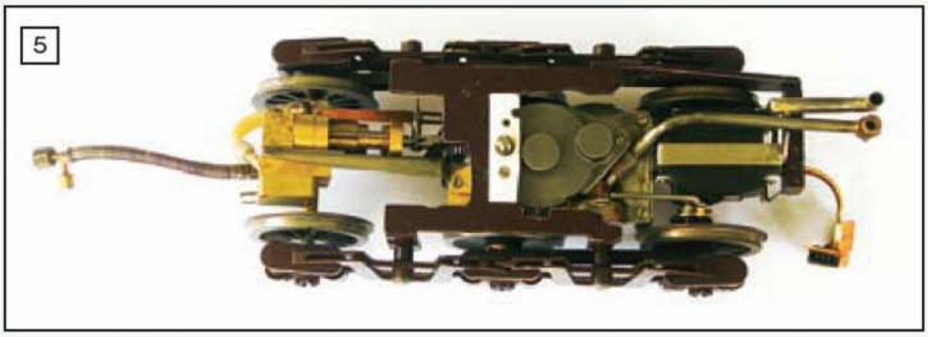
Boiler pressure (Bar)	Load voltage (V DC)	Load current (mA DC)	Shaft speed (rpm)	Calculated shaft power output (Watt)
4	25.0	54.0	41'430	1.35
4	21.0	66.0	36'210	1.39
4	20.0	79.5	34'680	1.59
4	17.5	97.5	30'710	1.70
4	13.3	118.7	24'310	1.58
4	12	129.3	22'660	1.55

Peak power output is at approximately 30,000rpm.

The speed target for *Der Mathematiker* is a scale speed of 200kph. With this speed the train can run without problems on a regular gauge 1 layout having a track radius of 3 metres. Reduced to actual speed (1/32), this works out to 104m/min or 1.73m/s. The locomotive has driving wheel diameters of 0.04m (40mm). To reach this speed, the wheels must spin at 828rpm. The reduction gear ratio required is therefore 30,000/828 = 36.2/1, say 36/1.

A well running gear train with a minimum of power losses is essential for the success of the whole project. The rather small power output at the turbine shaft should be available to the utmost extent at the driving wheels of the locomotive. The use of ball bearings is therefore a must! With this in mind, I built myself the gear train required. It consists of module 0.5 gear sets 10/60, 10/40 and the angle gear set 20/30 (**photo 4**).

Photograph 5 is the turbine unit as mounted into the truck. Main components are from left to right: feed water pump, turbine and servo. The white rectangle in the centre (Teflon) is the truck saddle. In its middle the push button type pivot. One of the two tooth belts is visible at the lower end of the 2nd and 3rd axle. The locomotive chassis can now be seen on the track (**photo 6**). The connections to the condenser tender are from top to bottom: exhaust steam hose, condensate overflow and condensate return hose to feed pump. **Photograph 7** shows what the front end of the train looks like. Its total length is 3.85 metres.



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Some information about the operational characteristics may be of interest to the reader. First the steam demand. It is high, much higher than for a corresponding piston drive. This is true not only for the Tesla turbine, but also for the previously built impulse turbine. The condensing tender is equipped with four electrically-driven cooling fans (SUNON,5V=, 1.9W). When running the train at ambient temperature of 20deg. C and 200kph with oscillating cylinder drive, condensation is maintained with one fan operating. For the turbines, at least two are required. The thermal exhaust energy is therefore much higher!

To be able to generate sufficient steam, the gas pressure in the liquid gas tank must be at or above 2 bar (for safety reasons Butane only must be used). The gas pressure depends on the Butane temperature. After an initial short period of operation, when the first stage condenser located in the locomotive itself is hot, the gas take off valve can be switched to 'liquid gas'. Evaporation and pre-heating of the gas then takes place in a separate compartment of the condenser. Thus, tank temperature and pressure loss due to gas evaporation inside the tank is avoided.

The reaction of the Tesla turbine is rather sluggish when compared to the finely controllable power output of a piston or impulse turbine drive. Precise stopping or shunting of the train requires some practice.

The running time of a fuelled up train on a level track at an average speed of 170kph, a hook force of approx. 0.6 Newton and a consumption of 80g Butane (corresponds to 140ml) and 300ml water (via leaks) is approximately 40 minutes. To

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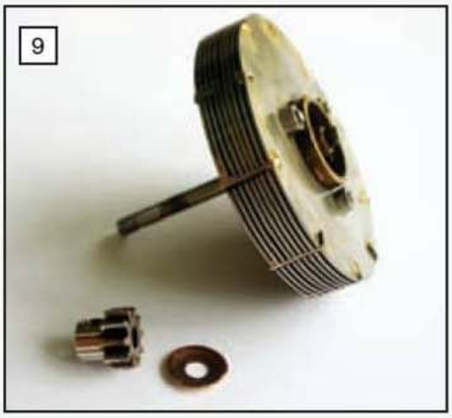
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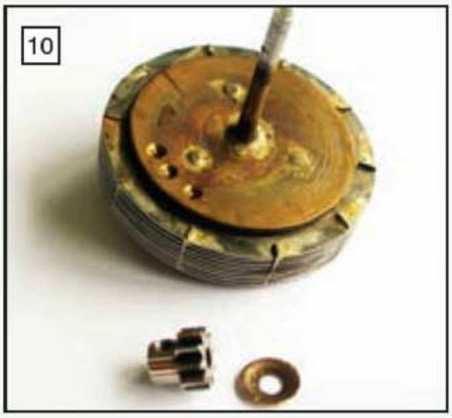
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have an idea of what to expect from a locomotive without feed pump and condensing tender I have run the train with the locomotive exhausting directly to the atmosphere. The 300ml water lasted for 15 minutes at a Butane consumption (without raising steam requirements) of approximately 30 grams. The consumption can be read off the level show glass in the cab, graduated in 10g steps.

One more practical experience: After four running hours, the upper ball bearing of the turbine failed. I'm not sure about the reason, but it could have been lack of lubrication. A small pipe leading to the truck exterior has now been installed. Prior to each run, a small quantity of WD-40 lubricant is squirted onto the bearing.

Let's make a quick calculation about the efficiency of the locomotive, based on the 15 minute running time mentioned above. The lower heat value of Butane is 12.7 kWh/kg or 45,720 Ws/g. A consumption of 30g in 900 seconds results in a power input of 0.0333g/s x 45,720 Ws/g = 1524 Watt. This is approximately the power consumption of an electric iron.

The force required to move the whole train including reduction gear and turbine is approx. 0.9 Newton. The corresponding force required to move tender and coaches only (useful load) is 0.6 Newton. Both these forces have been measured with a spring scale and practically do not vary with speed.

At scale speed of 170kph, the actual train speed is 1.48m/s. With these figures, power output at the turbine shaft is 0.9 N x 1.48m/s = 1.332 Watts. The power available at the track, the useful power, is 0.6 N x 1.48m/s = 0.876 Watts.

Now, what is the overall efficiency?

(0,876W/ 1524W) x 100 = 0.06% - disgracefully low!

Let's be generous – let's agree on 0.1%. In other words, 99.9% of the theoretically available power beats it by way of bad combustion, hot exhaust gasses, boiler radiation, steam flow losses, bearing and valve leaks, exhaust steam heat content and gear and bearing losses. Additionally, I better not think of the condenser cooling fans. They also eat power!

What the heck! *Der Mathematiker* is running beautifully as long as there are no mountains to climb and enthuses kids and adults alike – and this, after all, is its mission!

Constructional details

A series of pictures of the components with corresponding technical data will help in designing your own turbine. But first a word of caution. The best turbine will not run satisfactorily if it does not get sufficient steam! So - make sure, your boiler is capable of maintaining pressure while blowing off through an orifice of say Ø 0.7 to 0.8 millimetres.

Rotor disks; photo 8

Stainless steel 0.3mm. Bore Ø 10mm. Bolt circle Ø 13mm. Bolt hole Ø 1.4mm. Outer Ø prior to turn down (after assembly) 30.3mm. Spacer rings 0.3mm, bore Ø 1.4mm, outer Ø 2.8 millimetres.

Rotor, side view; photo 9

The following parts are all stainless steel: Shaft Ø = 2mm, length 28mm. Nine discs 0.3mm, Ø 30.3mm. Three bolts M1.4. Spacers between discs 0.3mm. Spacer combs inserted in slots cut after assembly of the discs. Rotor hub made of bronze. In front: Gear module 0.5, 10 teeth, surface hardened, with setting screw M2. Disc spring Ø 6mm made out of 0.25mm bronze for minimal lateral play of the rotor.

Rotor, rear view; photo 10

Shaft and bolts brazed (silver solder). Ten spacer combs 2.3 x 6 x 0.3mm with 0.3mm slots of 0.5mm depth. They are inserted into disc slots of 1.5mm depth and brazed to the outer disks. Balancing pits can be seen on the left side. Prior to balancing, the rotor has to be turned down to the final diameter of 30.0 millimetres.

Rotor, front view; photo 11

Hub made out of bronze, Ø 24/10mm. Behind the shaft end one of the three exit steam openings can be seen. Since the turbine had to fit into an already existing gauge 1 truck, quite a few dimensional limits had to be observed. This included the space for the steam inlet valve and corresponding jet slots in the casing.

Turbine casing; photo 12

Stainless steel, consisting of a 2mm rectangular base plate, brazed in journal Ø 10mm, length (8 + 2 =10mm). Journal holds two ball bearings 2 x 6 x 2.5mm and three spacers between the bearings 2.3 x 6 x 1.6. The spacers have a Ø 4 x 0.5mm recess on each side. This semi-labyrinth hopefully will slow down escaping steam. At the bottom brazed in casing ring Ø 33/29mm, length 12mm. The unit is to be finished in the lathe to Ø 32/30.2, L = 11mm. The slots for the steam jets were machined and filed afterwards.

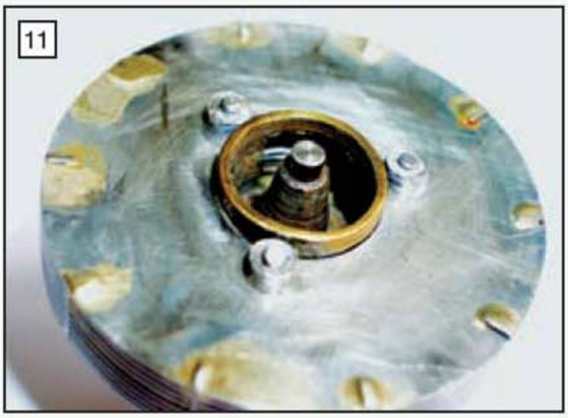
Turbine, partly assembled; photo 13

Gear unit slipped over the casing journal. The rotor can be seen through the steam jet openings. Turbine cover with exhaust steam hose adjacent. Below (flipped 180deg.) incoming steam pipe 4 x 3.5mm and the two jet slots. All three are brazed to the bronze body of the two-way valve. The jets are made out of stainless steel pipe 3 x 2.5mm, on one side squeezed together with a 0.2mm shim inside and then angled. The space between valve and casing ring is filled with Epoxy.

Steam 2-way valve; photo 14

In the upper right is the valve part shown also in picture 06, this time seen from the reverse side. The intermediate graphite – Teflon sealing disc Ø 18mm x 0.7mm is visible. It is held in place by the Ø 2mm centre shaft and the jet pipe ends, protruding 0.5mm into the disc.

To the left lies, flipped 180deg., the movable valve part. Actuator link to servo at top and manual lever at bottom. The three valve orifices lead to a common ring chamber inside. The disc spring Ø 20mm is made out of 0.4mm bronze sheet. It is placed on top of the movable valve part. Valve sealing pressure can then be adjusted via the M2 nuts.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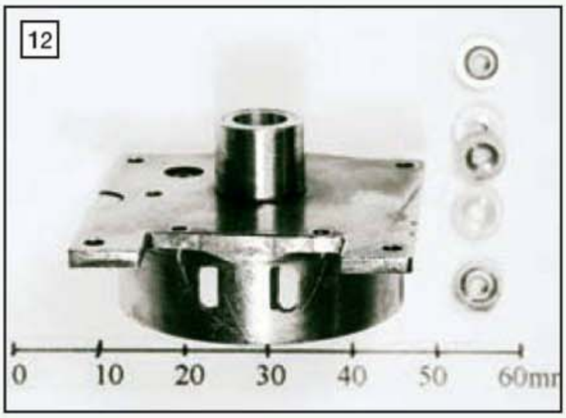

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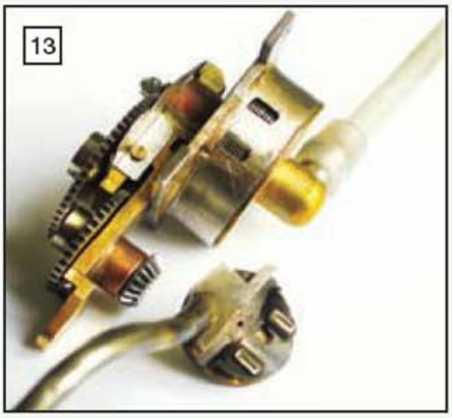

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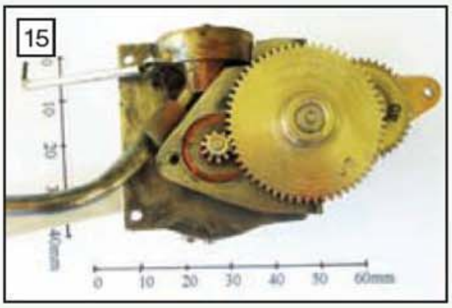
Turbine, seen from top; photo 15

First gear set 10/60, second set 10/40 teeth. Below the gear the base plate of the gear protection hood. To the left steam is the admission pipe (the short piece of silicon tube allows for insertion of a thermocouple to monitor steam entry temperature). Above is the two-way valve with actuator link to servo.

Turbine, side view; photo 16

To the right is the angle gear (20 teeth), which engages its counterpart (30 teeth) sitting on the truck axle.

In front of the casing is a brazed on pressure equalising conduit. Its function is to take steam pressure off the ball bearings. To the right is the M 1.4 screw holding the turbine exhaust cover.



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My initial attempt with a gear train using module 0.3 gears was not very successful. Module 0.5 gears proved to be better suited. They are standard gears of steel (11SMnPb30), which have to be machined to size. Depending on application, tooth widths of 1.5 to 4mm are required and gears are fixed to the shaft with a set screw or a press fit. The biggest problem, however, is the wear on the fast running teeth. I have tried to get it under control by chemically and electrolytic nickel-plating the gears. Then I tried chromium plating. All to no avail! After a run of about a quarter of an hour, the plating was gone and the teeth were deformed visibly. As a last resort, I had the gears professionally surface hardened. *"For module 0.5 to a maximum depth of 0.1mm"* the boss told me, *"otherwise the teeth might break off!"*. For corrosion protection, the gears were then additionally nickel-plated.

This approach seems to be successful. The gear pinion has been operating for four hours at an average of 27,000rpm – and still looks good.

Central drive unit for the three-axle truck; photo 17

From left to right: Exhaust steam pipe, stainless steel Ø 5 x 4mm. Above ball joint allowing for free movement of the unit within the truck. Plug, cable holder and servo. Empty space to accept turbine unit. Drive axle Ø 3mm with driving wheels Ø 40mm. The axle is equipped with two ball bearings 3 x 8 x 3mm, angle gear module 0.5, 30 teeth, gear 12 teeth, tooth belt drive wheels 16 teeth (located outside the driving wheels) and axle stub for the truck ball bearings.

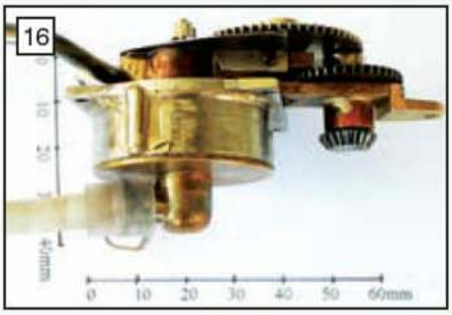
Further to the right is the gear (38 teeth) with the eccentric pin for the feed pump, the pump with mechanically operated inlet valve and the silicon hose to the fine mesh water filter above. Still further to the right is the pressure hose to the boiler check valve, with a take off connection to the bypass valve.

14

Turbine, placed into the unit; photo 18

The mounting screws M2 (two at left, one at right) are not yet inserted. The attentive reader may have noticed that the driving wheels of the unit do not have spokes. The reason is simple, I run out of castings! Since I had procured them more than 15 years ago I judged the effort required to get identical ones as too onerous. And anyhow, my locomotive is a prototype. So I machined the wheels out of steel plate.

This is the end of my report and hopefully it has provided some inspiration to fellow model engineers. Why not give it a try – and good luck!



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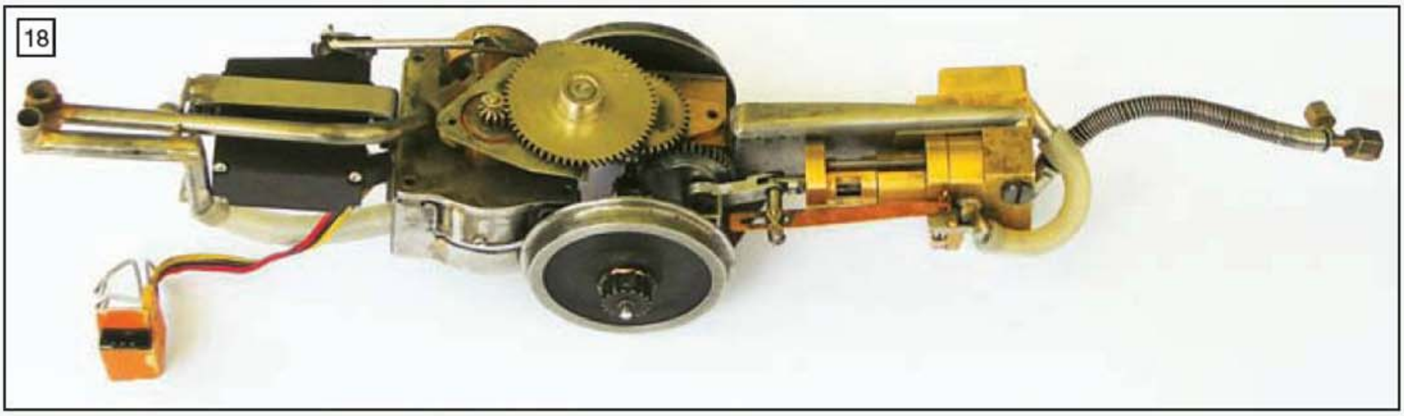
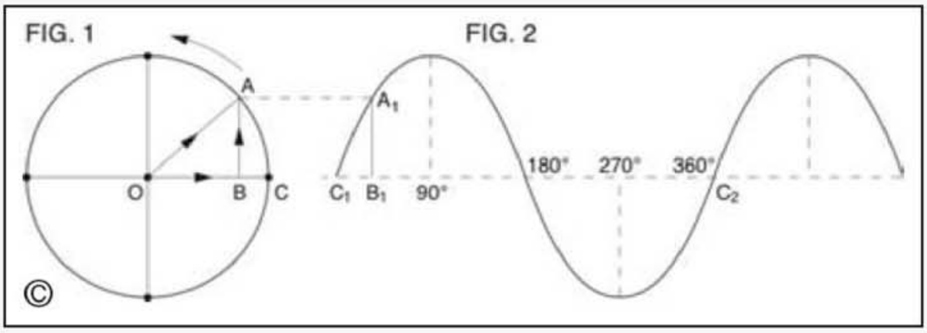


18

M. J. H. Ellis
continues with Albert Michelson's illustrious career discussing his investigations into light.
●*Number 92*



LETTERS TO A GRANDSON

Dear Adrian, I think that I had better start by picking up the thread of Michelson's career once more. Following his return from Europe to the U.S. he obtained a value for the velocity of light of 299,855 km/sec. For many years it was not bettered, and. even then, it was he who did so.

In 1885 he was made professor of physics at the Case School of Applied Physics in Cleveland, Ohio, where he made improvements to his interferometric apparatus. By 1887 he was in a position to make known the results of his experiments. His finding was, that it made no difference in which direction the Earth was moving in its orbit; no motion could be detected relative to the 'ether'. As I mentioned in my last letter, this cast serious doubt on the validity of the ether hypothesis, and it would not be unfair to say that Michelson had as good as sounded its death-knell.

I don't think it out of place for me to venture the following comment. Once a scientific theory takes root, people are usually loath to abandon it without a struggle. I am therefore surprised that, to the best of my knowledge, no rear-guard, action was ever fought in defence of the ether. If this were so, it may have been a tribute to the standing which Michelson had already gained among his fellow-scientists. However, Grandpa being Grandpa, I am going to exercise my powers of invention with the following 'theory':

"There is a simple explanation of the fact that no motion of the Earth relative to the ether can be detected. Obviously, the Earth, like any other material body, exerts an attraction on the ether, which then forms a mantle around it as it moves. In this respect, it constitutes an additional 'ethereal' atmosphere, which we can never detect, because, by definition, ether is not matter. Is it unreasonable to surmise that the ether partakes of the nature of the mysterious electric fluid, or is perhaps another manifestation of it? We know that when a body is electrically charged, it repels other bodies charged with the same kind of electricity. In like manner, if the Earth be supposed to have acquired a 'charge' of ether, no more ether would be attracted to it. Clearly, if the Earth is saturated with ether in this manner, it will be impossible to detect any motion with respect to it, for the good reason that none exists".

I feel quite pleased with that composition, and you will see now where your Dad's talent comes from. But to continue.

In 1869 Michelson became Professor of Physics at dark University in Worcester, Massachusetts, but before long he was on the move again, having been appointed in 1892 as the first Head of the Physics Department of the University of Chicago, Illinois, a post which he continued to hold until, his retirement in 1929. This illustrious career was further enhanced by the award of the Nobel Prize in 1907, followed by many other honours. *'Hawdd cynnau tan ar hen aelwyd'* (it is easy to light a fire on an old hearth) runs the Welsh proverb, so it need be no surprise that Michelson returned to the determination of the velocity of light in 1923. He used a base of 35km between two mountains in California, the distance between the stations being surveyed to an error of no more than 2.5 centimetres. He arrived at a value of 299,798km/sec., and this compares well with the present accepted figure of 299,792.458km./sec. I regret to tell you that his retirement was not a long one, as he died on 9 May 1951, aged 78.

I see much for the model engineer to admire and seek to emulate in the life of Albert Michelson. He had vision, resourcefulness and patience in great measure, combining theoretical insight on the one hand with practical ingenuity on the other. In this he resembled Lord Kelvin, and it would make an interesting subject for debate, as to which of them, in their different ways, did the most good in the world. The late Paul Eddington, a distinguished British actor, hoped that it would be said of him *"He did very little harm"*, and I suggest that the two gentlemen whom I have mentioned are worthy, at the least, of the same epitaph.

Reading the foregoing has been easy enough for you, but I now have to warn you that like every road, Easy Street has to come to an end. In getting back to business, I shall do my best to make what I have to say about optical interference, and the inspired way in which Professor Michelson applied it to metrology as digestible as I can, but I have to confess that at times it has been hard going. So here we go, in easy stages.

(1) The nature of light

Light is an electromagnetic wave phenomenon, which is propagated in a vacuum with a velocity of approximately 299,800km/sec. Its velocity in a denser medium, such as glass, is considerably less. Were you to ask me how, or through what the wave is propagated, I don't believe that since the ether hypothesis was discredited there has been a simple answer to that apparently simple question. When I asked a physics graduate *"If matter is basically little packets of wave-motion, in what do those waves take place?"*, his answer was *"I can only answer that question in mathematical terms by describing them as waves in probability"*. It seems to me that there are times when the best we can do is to think in terms of analogy. A simple person, who understood an arch of masonry, might hope to explain the rainbow in a similar way. Of course, he would fail, but he could be given some kind of enlightenment in terms of mathematics. I am reminded of the words of wisdom attributed to J. B. S. Haldane, *"The universe is not only stranger than we imagine, it is stranger than we can imagine"*.

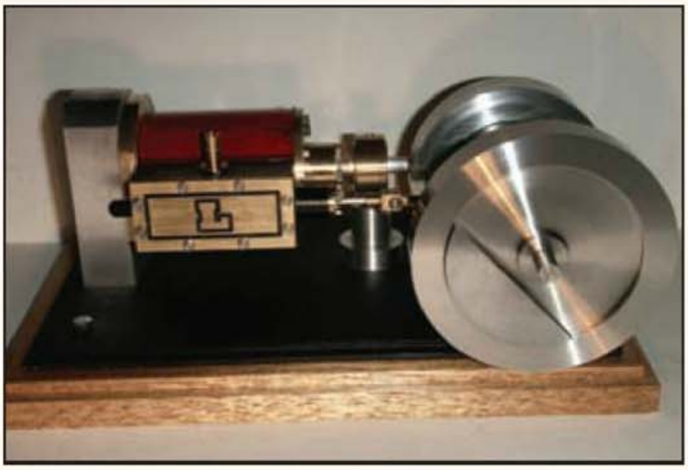
A micron, denoted by 'μ' is a millionth of a metre, and therefore a thousandth of a millimetre. The wavelength of light ranges from roughly 0.47μ in the violet to 0.66μ in the red. The middle of the range would be about 0.56μ. 1in. = 25.4mm, therefore 1mm = 1/25.4in. = 0.039 in., = 39thou.

Hence, 0.56μ = 0.56/1000mm., = 0.56/1000 x 39thou. = 0.022thou. That is about 1/45th of a thou, which isn't very much, but it does give an idea of the length of a light-wave. While we are about it, we may as well calculate the frequency of the vibration as follows:

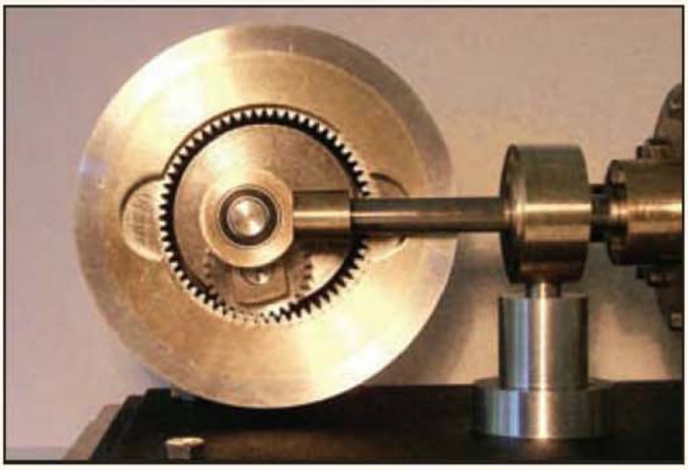
Length of one wave = 0.56μ, therefore 1μ contains 1/0.56 = 1.786 waves. In one second light travels 229,800km, = 2298 x 10^5 metres, = 2298 x 10^{11}μ, which comprise 2298 x 1.786 x 10^{11} waves. These pass any given point in 1sec., so that the frequency of the vibration is 2298 x 1.786 x 10^{11}, = 4083 x 10^{11} cycles/sec., or 408,300,000 megacycles/sec. Think of it, the tremendous range of electro-magnetic radiation, from radio waves with a wave-length measured in miles right down to X-rays, much shorter than the light-waves we have been talking about. I find it awe-inspiring.

Whatever the ultimate reality of light may be, for our purposes it can adequately be represented graphically by a sine-wave. I hardly consider it necessary to remind you (though I will) that a sine wave is simply a graph which represents the changing magnitude of the component in one particular direction of a vector which rotates with constant angular velocity. Put precisely like that, some people (like your Dad) might find it difficult to comprehend, but my sketch (**fig 1**) should make it easy. OA is the vector, of constant length, here shown rotating in the conventional anti-clockwise direction. It is resolved into two components at right-angles to each other, OB and BA. The graph, (**fig 2**) merely shows how the length of BA varies as OA rotates. Starting at C, where A coincides with C, its value is zero. When OA reaches the position shown in fig 1, the ordinate B, A, is equal to BA. When OA has rotated though a right angle, it reaches a maximum equal to OA, and when it has completed a half circle, it falls to zero again. Then follows a similar, but negative half-cycle as the vector returns to its starting point (represented on the graph by C_2), after which the graph repeats indefinitely in the same way. This kind of oscillation is called Simple Harmonic Motion (S.H.M.), and it is very often met with, since it arises whenever a, body, displaced from its position of rest, is subjected to a restoring force proportional to the displacement. Ha ha! more to come.

Your affectionate Grandpa.



View of the engine from the flywheel side showing its embellished valve chest cover.



Close-up view of the gearing used in the hypocycloidal crankshaft of this novel engine.

HYPOCYCLOIDAL DOUBLE ACTING ENGINE

Les Kerr
of Australia continues construction starting with item 8, the shaft.

●*Part II continued from page 134 (M.E. 4279, 4 August 2006)*

I fabricated the shaft from a 31mm length of 8mm dia. 304 stainless steel and a piece of brass turned to size for the end. I joined them together using Loctite 602.

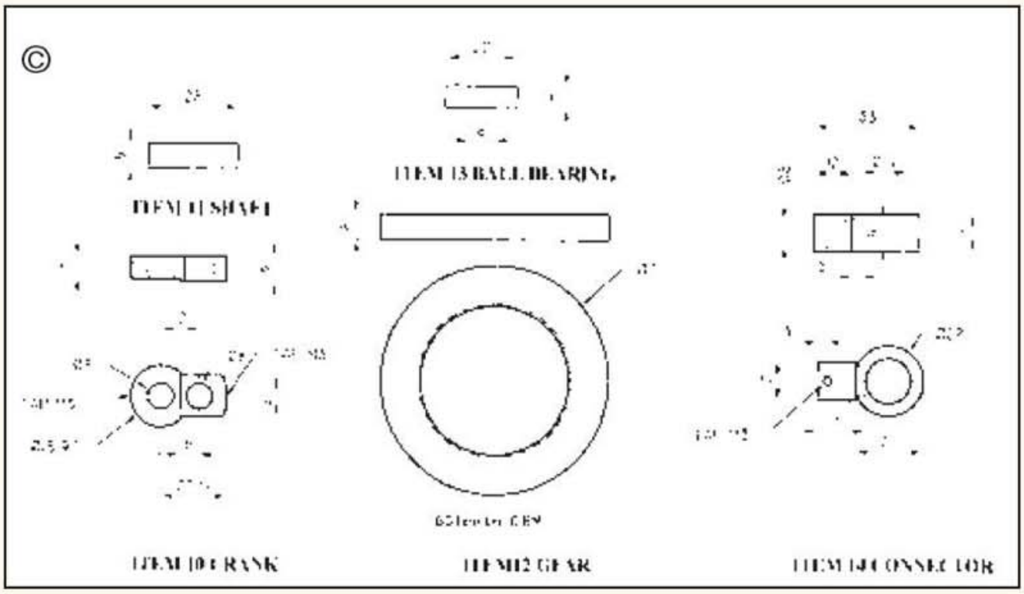
Ball race (item 9)
Purchased item (4 required). I/D 8mm, O/D 14mm, thickness 4mm sealed type.

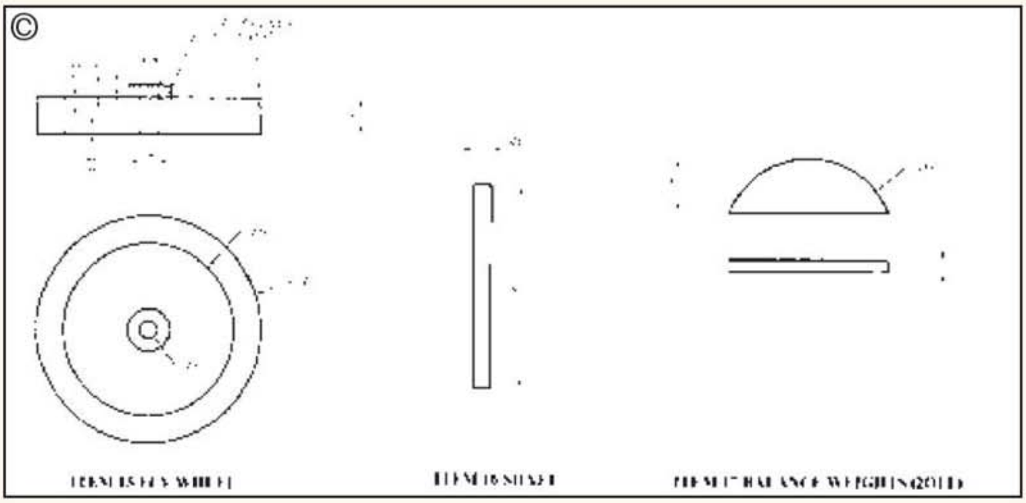
Crank (item 10)
Mine was made from brass. Again be as accurate as possible with the 12mm distance between the holes. The 18.97mm dia. radius was cut using the rotary table on the milling machine.

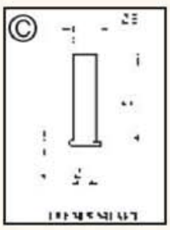
Shaft (item 11)
This is made from a length of 8mm dia. 304 stainless steel.

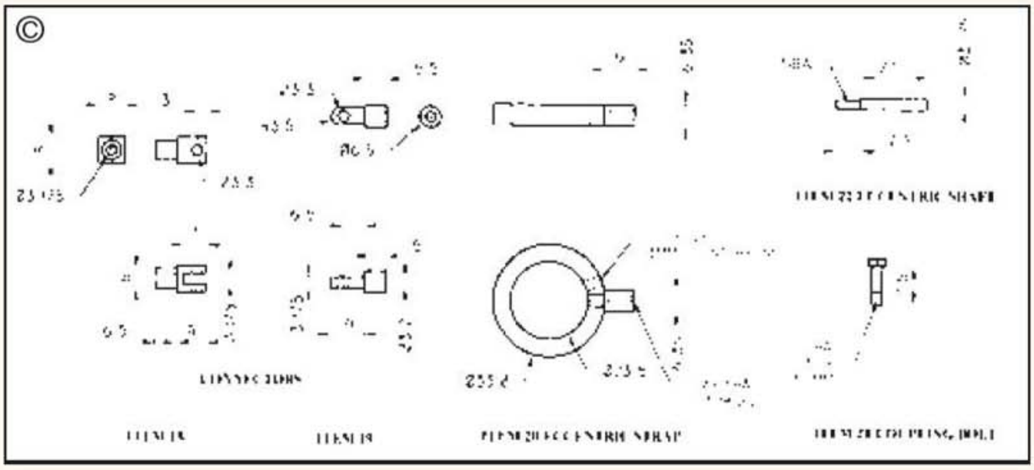
Internal tooth gear (item 12)
The internal tooth gear is 0.8 Module 60 teeth part number S1E08ZM08S060. It is made from 303 stainless steel has a face width of 8mm, PD of 48, ID 46.4mm and outside diameter of 100mm.

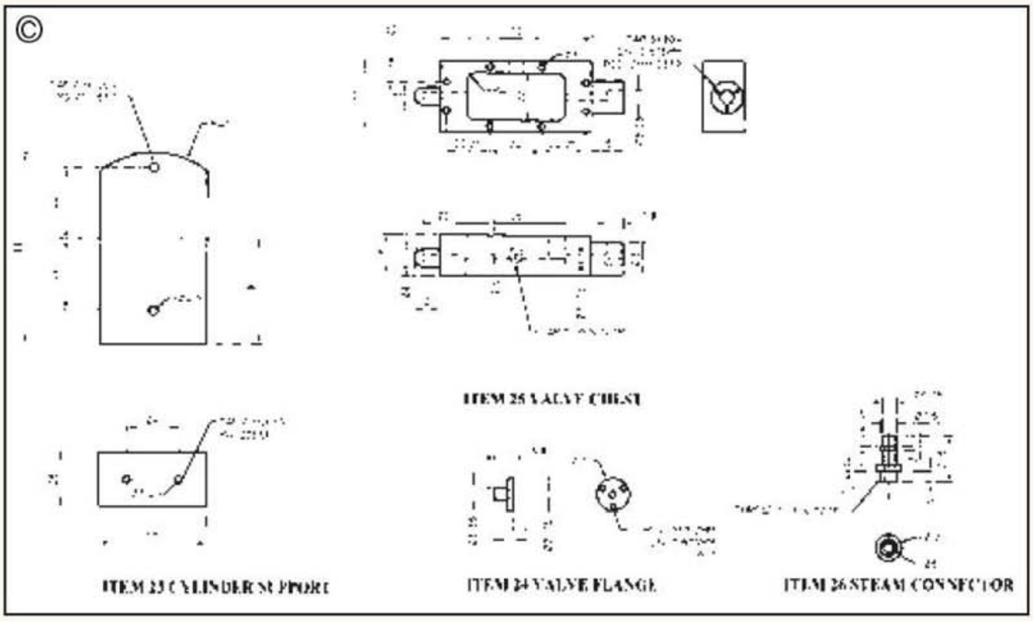
It can be purchased from Sterling Instruments (usual disclaimer). Their agents in Australia are Small Parts and Bearings and, in the UK, David Stock Gears. The O/D of the purchased, internal tooth gear has to be reduced to 71 millimetres. To do this make up a stub mandrel whose diameter is a tight fit in the I/D of the gear, then turn to size.

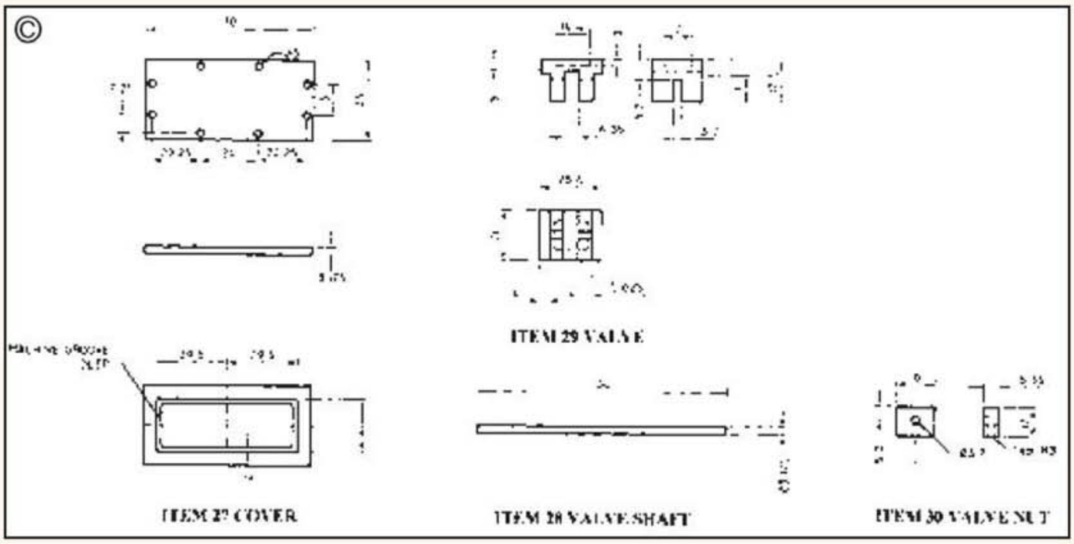












Ball race (item 13)
Purchased item (2 required). I/D 8mm, O/D 22mm, width 7mm, sealed type.

Connector (item 14)
This was made from brass and was fabricated from two pieces held together with 602 Loctite. The 14mm dia. hole is made to provide a press fit for the ball race.

Flywheel (item 15)
I made mine from 304 stainless steel but cast iron or brass would also be suitable depending on what you have available in your collection of odds and ends.

Shaft (item 16)
This was made from a length of 8mm dia. 304 stainless steel.

Balance weights (item 17)
These were made from 304 stainless steel but, again, brass or cast iron could be used. I made them by cutting up a section of round material. They were glued onto the flywheel with two part epoxy resin.

Connectors (item 18 and 19)
These were made from brass. I have found that it is best to cut the slot first. So that you can get a good grip on it to machine the other end I have found that it is worth the time to machine up a piece of metal to temporarily fit into the slot.

Eccentric strap (item 20)
This was fabricated from two pieces of brass held together with 602 loctite.

Coupling bolt (item 21)
Made from a 5BA mild steel bolt.

Eccentric shaft (item 22)
This was made from a length of $^1/_8$in. dia. 304 stainless steel.

Cylinder support (item 23)
Made from aluminium alloy with a cross section of 50 x 25 millimetres.

Make sure that the cylinder mounting holes are accurately placed, as the height of the cylinder must match that of the gearbox for smooth running.

Valve flange (item 24)
Made from a piece of brass.

Valve chest (item 25)
This was machined from a solid piece of brass of cross section 0.75 x 1.5 inch.

Steam connector (item 26)
Also made from brass.

Cover (item 27)
Made from a piece of $^1/_8$in. thick plate brass. A decorative groove was cut using a 2mm slot drill.

Valve shaft (item 28)
Made from a suitable length of $^1/_8$in. dia. 304 stainless steel.

Valve (item 29)
Milled out of a piece of brass 1 x $^3/_4$in. in cross section. The final operation being to polish the face by rubbing it in a figure of eight pattern on a sheet of fine abrasive paper which was kept flat by placing it on a surface plate or, in default, a thick sheet of plate glass.

Valve nut (item 30)
This item is made from a piece of $^1/_4$in. thick plate brass. Next time we will complete the manufacture of the engine and deal with the assembly procedure.

●*To be continued.*

I/C TOPICS

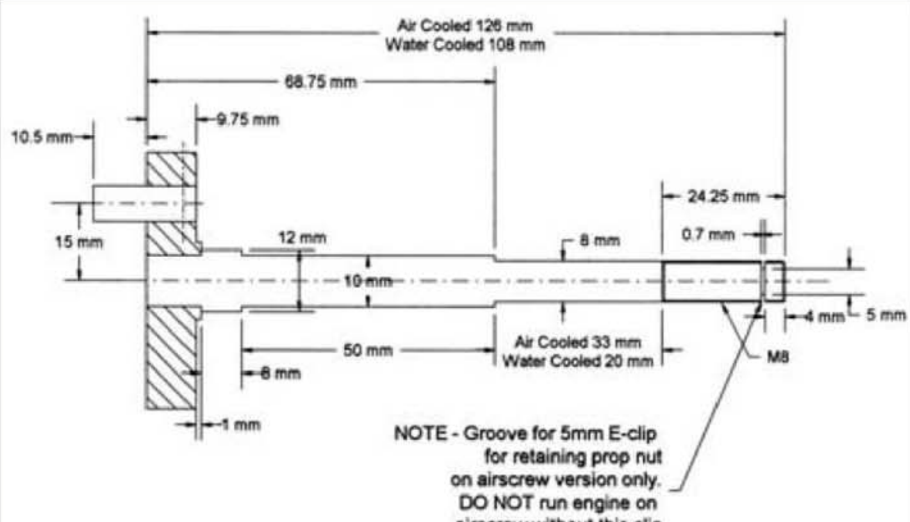
Nemett
continues the construction of the NE15S with some words on cam design and describes two methods of cutting cams without special equipment.

Before I start the main topics this time, I would like to thank all those who have purchased drawings and to say that the use of a box number means that it may take a week for the orders to reach me but I aim to despatch them within a couple of days so allow two weeks for the drawings to reach you, longer if outside the UK.

Important safety modification

Following an incident when a backfire caused the propeller to come loose and off the shaft (in spite of having a locknut in place) I have modified the crankshaft and propeller driver (not covered yet) to prevent this. The modification to the crankshaft involves the fitting of an e-clip (for 5mm groove) to the front end of the shaft. In order to do this a 0.7mm wide groove must be cut (**fig 1**) to leave a diameter at the bottom of the groove of 5mm. This latter dimension is critical in order to make the e-clip a tight fit. The engine should not be run on an airscrew without this clip in place. This change does not affect the marine version.

One other correction should also be made; the dimensions for the big end needle roller bearing on the purchased parts list in sheet 15 are incorrect. They should read 10 x 14 x 10 millimetres. The code number HK1010 is correct as are the relevant drawings.



© Figure 1 - Details of the important crankshaft modification

Cam design

The cams for I/C engines perform the task of opening and closing the valves at the correct points in the 4-stroke cycle. This cycle takes place over two full revolutions of the crankshaft and therefore with an engine running at 6000rpm the valves open and close 50 times a second. Because of this the shape of the cam is important if the tappet is to follow the cam contours exactly at this speed.

For a cam designed to work with the normal flat tappet, the cam contour is a series of curves (**fig 2**) which merge smoothly into one another. The curved parts are the base circle, the flanks and the nose.

The curved cam faces mean that the tappet always has a line contact with the cam. It is important to remember that the point of contact will move across the tappet as the cam rotates so the tappet must be of sufficient diameter to

Figure 2 - A typical cam showing the various parts of the profile

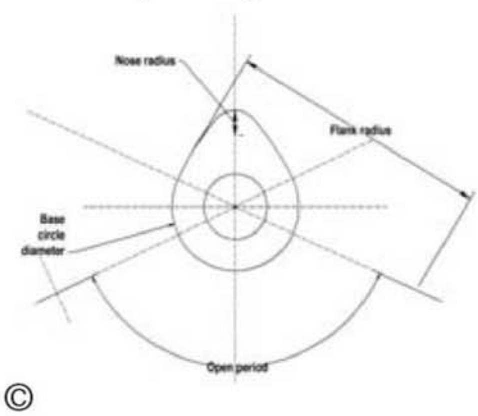


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Figure 3 - A typical engine timing diagram showing all the strokes

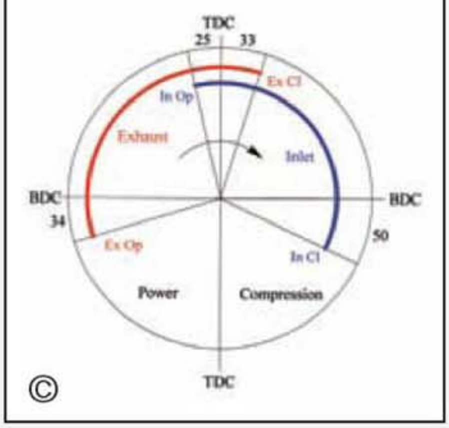

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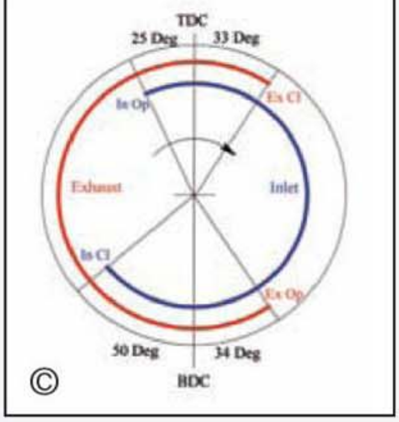
Figure 4 - The more common type of timing diagram for the same engine



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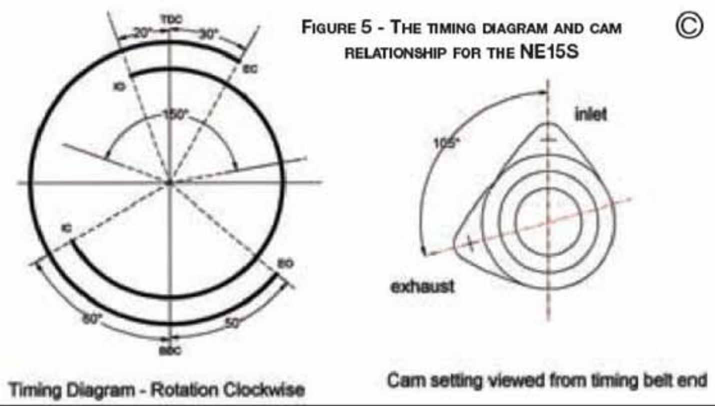
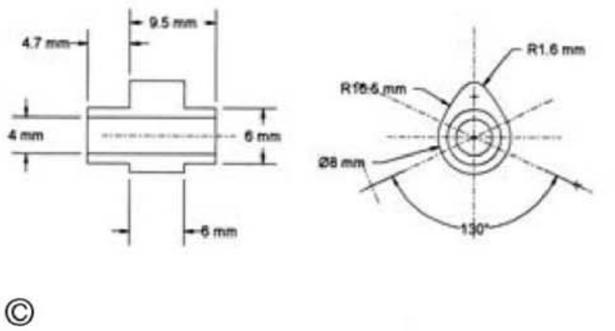


Figure 5 - The timing diagram and cam relationship for the NE15S ©

Timing Diagram - Rotation Clockwise

Cam setting viewed from timing belt end

Figure 6 - The cam drawing for the NE15S



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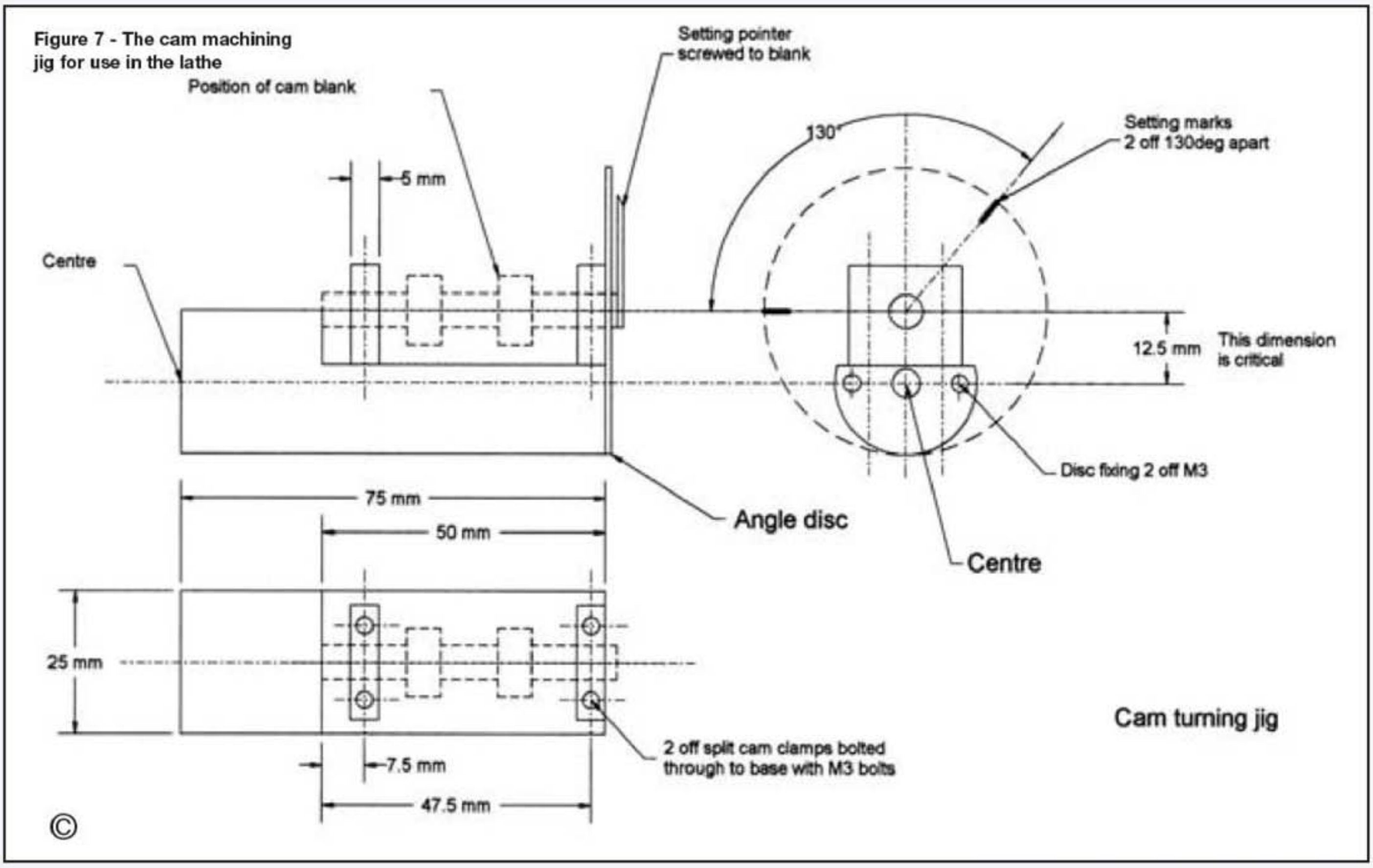
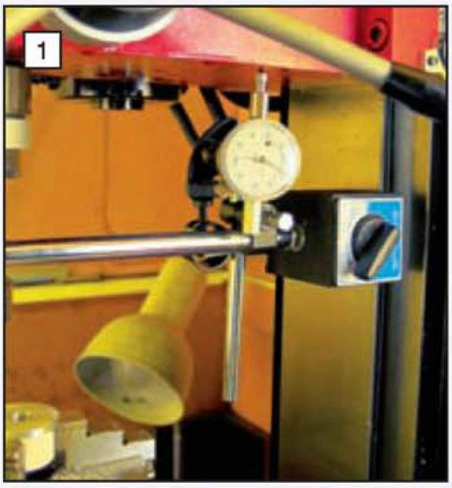
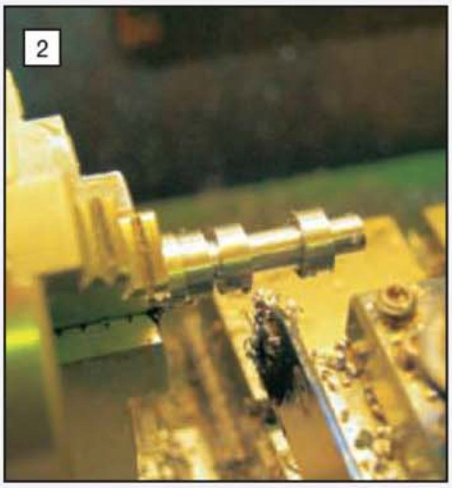




Using a dial gauge for accurate measurement of milling head movement.



When turning the cam blank leave it attached to the parent bar.

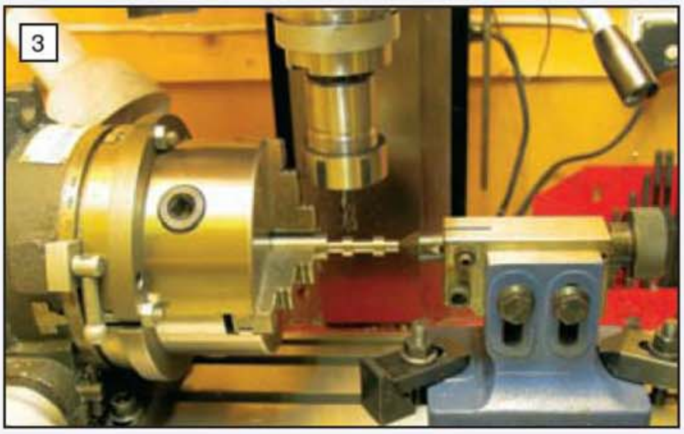
ensure that the cam never overlaps the edge of the tappet.

For cams operating with roller tappets, as in some horizontal gas engines, the cam flanks can be straight provided the roller is large enough.

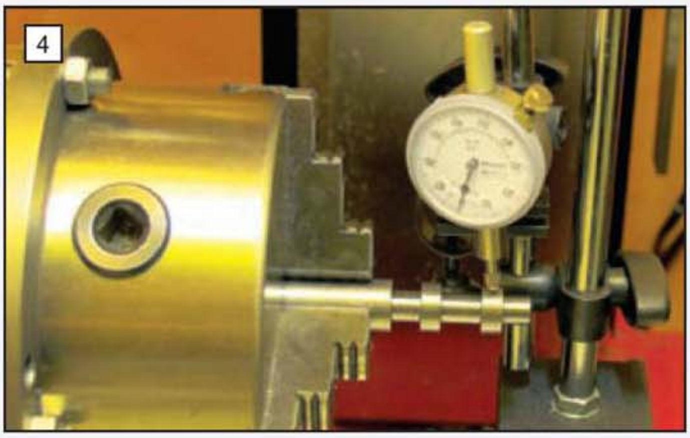
The basic design points of the cam are the opening period and the lift. Setting these two parameters will then help to define the other details such as the base circle diameter and the nose radius. The base circle is the diameter of that part of the cam in action when the valve is closed.

In order to provide smooth operation, the cam flanks are curved and this curve is generally set at around twice the base circle radius.

When designing cams, readers will find that if the base circle is too small and the opening period is short, the desired lift may not be possible because the flank curves will meet at a point lower than the desired lift. In this case, the base circle and hence the cam will need to be made larger. A few experiments with pencil and paper or a CAD system will show the effects.



The setup for cutting cams in the milling machine.



Checking that the cam blank is rotating truly.

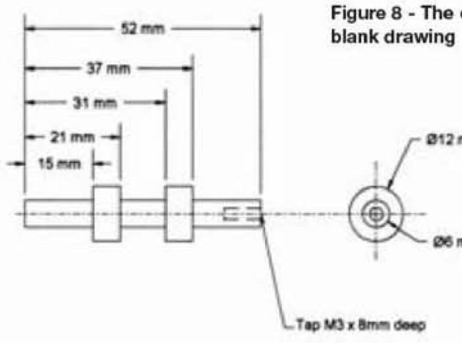


Figure 8 - The cam blank drawing

Cam blank - for use with jig

©

Remember also that because the camshaft is turning at half crankshaft speed, the opening period of a valve is twice the angle between the opening and closing points on the cam.

For any pair of exhaust and inlet cams, another important parameter is the valve overlap. This is defined by the relative positions of the cams to each other on the shaft and is the time that both valves are open together around top dead centre on the induction stroke. This overlap is necessary because the gases take a finite time to accelerate in and out of the cylinder and if overlap was not allowed, the engine would be inefficient and would tend to be slow revving. A smaller overlap period will help to make an engine less critical and such engines will tend to throttle better.

The valve events are expressed by means of a timing diagram which can take two forms, one which shows all the strokes (**fig 3**) and one which shows just two strokes (**fig 4**), missing out the power and compression strokes. I think the former is easier to follow for those new to such things. The timing diagram and cam relationship for the NE15S is shown in **fig 5**.

Figure 9 - The cam cutting data for use with the milling machine ©

Produced by Camcalc Version 1.1 courtesy of Ron Chernich.

Cam Open Angle (degrees):	130
Valve Lift (mm):	2
Flank Radius (mm):	16.5
Base Radius (mm):	4
Engine Speed (RPM):	5000
Nose Radius (mm):	1.592
Tang follower width min (mm):	6.654
Max acceleration (g):	85
Min acceleration (g):	-29
Lift Area (mm degrees):	152.405
Nose Transition delay (degrees):	15.55

Angle Degrees	Lift mm	Angle Degrees	Lift mm	Angle Degrees	Lift mm
295	0	**339**	1.71	**22**	1.68
296	0	**340**	1.73	**23**	1.65
297	0.01	**341**	1.76	**24**	1.62
298	0.02	**342**	1.78	**25**	1.59
299	0.03	**343**	1.81	**26**	1.55
300	0.05	**344**	1.83	**27**	1.52
301	0.07	**345**	1.85	**28**	1.48
302	0.09	**346**	1.87	**29**	1.45
303	0.12	**347**	1.89	**30**	1.41
304	0.15	**348**	1.90	**31**	1.37
305	0.19	**349**	1.92	**32**	1.33
306	0.23	**350**	1.93	**33**	1.29
307	0.27	**351**	1.95	**34**	1.25
308	0.32	**352**	1.96	**35**	1.2
309	0.37	**353**	1.97	**36**	1.16
310	0.43	**354**	1.98	**37**	1.11
311	0.48	**355**	1.98	**38**	1.07
312	0.54	**356**	1.99	**39**	1.02
313	0.60	**357**	1.99	**40**	0.97
314	0.65	**358**	2.00	**41**	0.92
315	0.71	**359**	2.00	**42**	0.87
316	0.76	**0**	2.00	**43**	0.82
317	0.82	**1**	2.00	**44**	0.76
318	0.87	**2**	2.00	**45**	0.71
319	0.92	**3**	1.99	**46**	0.65
320	0.97	**4**	1.99	**47**	0.6
321	1.02	**5**	1.98	**48**	0.54
322	1.07	**6**	1.98	**49**	0.48
323	1.11	**7**	1.97	**50**	0.43
324	1.16	**8**	1.96	**51**	0.37
325	1.20	**9**	1.95	**52**	0.32
326	1.25	**10**	1.93	**53**	0.27
327	1.29	**11**	1.92	**54**	0.23
328	1.33	**12**	1.90	**55**	0.19
329	1.37	**13**	1.89	**56**	0.15
330	1.41	**14**	1.87	**57**	0.12
331	1.45	**15**	1.85	**58**	0.09
332	1.48	**16**	1.83	**59**	0.07
333	1.52	**17**	1.81	**60**	0.05
334	1.55	**18**	1.78	**61**	0.03
335	1.59	**19**	1.76	**62**	0.02
336	1.62	**20**	1.73	**63**	0.01
337	1.65	**21**	1.71	**64**	0
338	1.68				

29 Cams

There are two methods of machining the cam (**fig 6**) profiles without resorting to special machinery. Cams can be cut in the lathe with a jig or by using a rotary table in the milling machine in conjunction with a calculated table of offsets. In both cases the cams will be machined as one and then drilled before being separated to be Loctited onto the shaft in the correct relationship. I prefer the milling method, but have included drawings for a cam turning jig for those who wish to use that method.

Using the Lathe

For those using the lathe, this is the method described by Edgar Westbury for a number of his engines. The first thing is to make up the jig as per the drawing (**fig 7**) and then to turn the cam blank (**fig 8**) and tap the end hole for the pointer. The offset between the cam blank centre and the rotating centre on the jig is the critical dimension as this fixes the flank radius and base circle diameter.

Set the blank in the jig and bolt the pointer to the shaft with its end lined up with the zero mark. Set the jig in the chuck and bring a supporting centre up to the end. Check that everything can rotate without fouling.

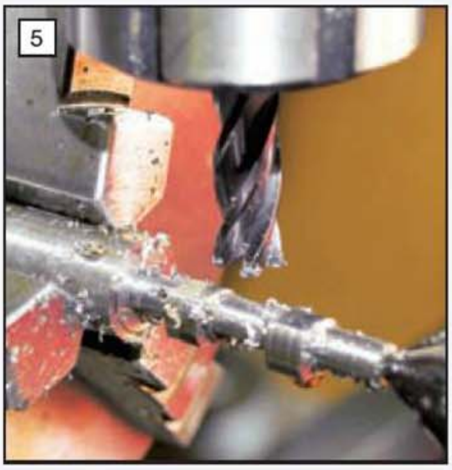
Set a sharp lathe tool to just touch the cam as the lathe is rotated. Zero the top slide (or digital readout). Take a series of light cuts over both cams to remove exactly 2mm of metal. This will leave one cam flank showing. Zero the index or cross slide dial at this point.

Loosen the blank in the jig (but don't loosen the pointer on the cam blank) and rotate the blank until the pointer is aligned with the 130deg. mark. Repeat the machining process for the other flank on both cams, cutting down to the previously set zero.

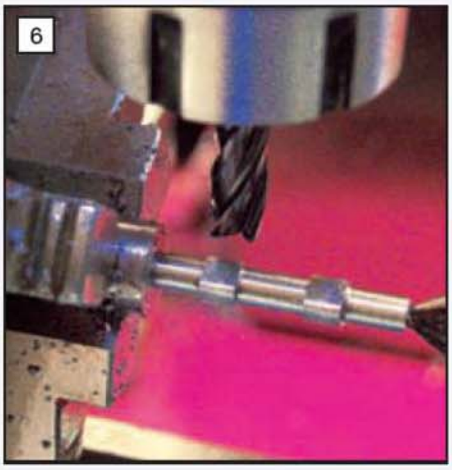
The nose of the cam should be a small flat between the flanks. Mark this with an indelible marker to avoid confusion later.

Now rotate the blank a couple degrees (estimated) past the 130deg. mark and repeat the process to start producing the back of the cam (the base circle). Repeat this process until the 0deg mark is reached. This should leave the base circle as a series of small flats which will be tidied up later. Obviously the smaller the rotation between each cut the better.

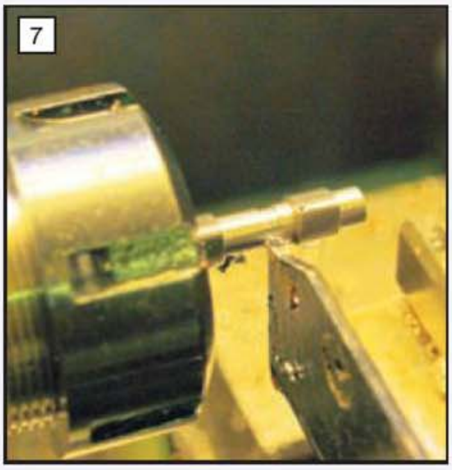
Remove the cams from the jig and with them still as one piece use a fine (diamond) file to



Taking a cut on the cam.



The cam cutting process finished.



Parting off the cams to length.

clean up the faces and base circle and to form the nose radius. Keep the file across both cams to ensure that the surfaces remain parallel to the shaft axis. Aim to get a good polish on the cams.

Using the milling machine

I have mentioned Ron Chernich's excellent website (**www.modelenginenews.org**) before and this contains a superb program for calculating the lift of the cam at intervals during rotation. This can be used to cut the cams in the milling machine. The full set of milling offsets for the NE15S are included here (**fig 9**) and on the drawings.

This process is made much easier if the milling machine has a digital readout on the Z axis. If not, set up a dial gauge under the milling head to measure the movement (**photo 1**). A dial gauge could also be used if milling the cams in the lathe. Unless you are very confident of your machine, it is not sensible to use the machine indexes here because we are dealing with very small increments between cuts.

Turn the cam blank (**photo 2**) as before but this time leave it attached to the parent bar to enable it to be held in the chuck on the rotary table and just centre the end, we do not need the thread for this method.

Set up the rotary table so that the chuck axis is horizontal and set a centre to support the end of the cam blank. The full setup I used is shown in **photo 3**.

Ensure that the blank rotates truly (**photo 4**), shimming or using the 4-jaw chuck if necessary.

Set the rotary table to 295deg. (just before the beginning of the flank) and put a 10mm end mill or slot drill in the machine. Bring this down to touch the cam surface and zero the readout or dial gauge.

Now take a series of light cuts across both cams until 2mm has been removed. Zero the Z axis readout at this setting.

Rotate the table to 296deg. and repeat the cut and then rotate the table to 297, lift the tool 0.02mm and take another cut. Repeat this process **photo 5**) using each lift value in the table until the flanks and nose have been cut. Once the '0' (the cam nose position) on the rotary table has been reached, the cut decreases with each increment.

Note also that the lift figures are the total lift for any particular cut, not the increment between cuts.

Then with the Z axis locked at zero, index round the base circle in the same way as for the flanks but without altering the Z axis setting until reaching 294deg. (**photo 6**) on the rotary table.

During this process it pays to have the vertical movement on the mill set fairly tight so that the cut can be taken without having to lock the head each time.

The cams will have a series of very fine flats, visible only under a magnifying glass. With the cams still in one piece, use a diamond file across both cams to lightly clean up the working faces to leave a smooth polished finish. Transfer the blank to the lathe and ensure that the cam runs truly before drilling the shaft hole 3.9mm.

Measure the distance between the inner ends of the camshaft bearings and subtract 13mm (final distance between the outer faces of the cam sides) from this. Now part off the cams from the bar (**photo 7**) leaving half this resulting measurement of the spigot on each cam. This will be the outer end of each cam when assembled. Put each cam in the collet chuck (make a split chuck if you do not have a collet chuck) and face the short (middle) spigot to 3.5 millimetres. This should result in the cams just fitting between the bearings. Ream the bores at this setting.

Now check the finish on the cams, mark to identify them, case-harden and finally polish. When case-hardening, I placed each cam in a small container of case hardening compound and heated the whole lot up to red heat before quenching. Repeat the process to achieve a thicker depth of hardening.

Setting the cams on the shaft

The camshaft is a piece of 4mm dia. silver steel 90mm long. The easiest way to set the cams in the correct relationship (105deg. apart with exhaust leading) is to use the rotary table on the mill table and a simple locating jig.

The jig consists of a short length of mild steel bar with a notch cut into one edge with a triangular file. This slot will locate the nose of the cams.

The bar is clamped to a V-block such that the notch locates closely on the camshaft when the shaft held in the chuck on the rotary table with the V block stood on the milling table.

The rotary table is set to zero and the shaft and cams are cleaned and degreased with cellulose thinners and allowed to dry. The inside of the cams can be cleaned with cellulose thinners on a clean piece of clean lint free cloth. After that do not touch the shaft where the cams will fit with the fingers.

The inlet cam is now fixed to the shaft with Loctite 603 at the correct distance from the end (check from cam box and cylinder head) and allowed to cure. Make sure the longer spigot on each cam is to the outside of the camshaft.

When the Loctite has cured set the shaft in the rotary table with the cam located in the jig and the exhaust end of the shaft outwards. Remove the jig and rotate the rotary table 105deg. in a clockwise direction looking from the exhaust end.

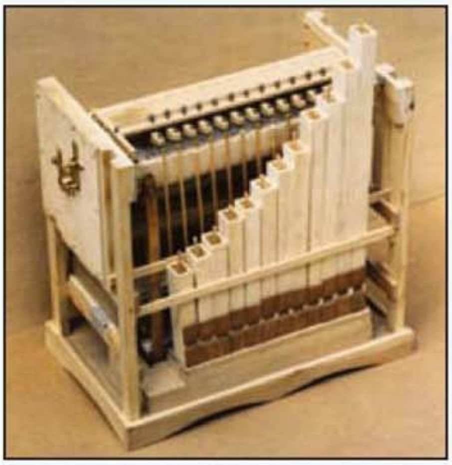
Now fix the exhaust cam in position (**photo 8**) using the jig to locate the nose to provide the correct orientation to the inlet cam. Leave to cure before removing any excess Loctite with thinners and giving the cams a final polish. The camshaft (**photo 9**) is now complete.

Next time I will start with setting the valve stem length and setting up the valve timing.

●*To be continued.*

Setting the exhaust cam in position using the simple jig and rotary table.

The finished camshaft.



Front view of the experimental barrel organ that forms the subject of this series of articles.

A SMALL BARREL ORGAN

David Wilcox
introduces us to a delightful project with a musical theme.
● *Part I*

Regular readers of this magazine will recall that *M.E.* 4218, 2 April 2004 contained my article on the construction of the John Smith Busker Organ and for which plans are available. This organ has 20 pipes and works on the perforated paper roll principle. Whilst I made a number of substantial modifications to John Smith's plans, it worked well and it whetted my appetite for more. I should at the outset stress that I am not a musician, I have never been taught music but I have picked up enough from children's 'introduction to the piano' type books to get by.

Whilst seeking to learn more about mechanical music, I came across three books on the subject: *The Barrel Organ* by A.W.J.G. Ord-Hume (a rare book); *The Fairground Organ* by E.V. Cockayne and *Waldkirch Street and Fairground Organs* by Herbert Juttermans. This latter book is available from Camden Steam Services. Part of this last book is given over to how early 19th century barrel organs were constructed. There was clearly much more mechanical content and model-engineering scope in a barrel organ compared with a perforated roll organ. From my small library I decided I had enough at my disposal on the working principles to be able to design and make an example of a small barrel organ, if only to demonstrate the principle of operation.

Historically, barrel organs came first and were commonplace in the latter half of the 18th century. In the 19th century, every town in northern Europe would have had its street musicians, sometimes equipped with monkey and stick organs or, particularly in Holland, with larger organs mounted on small hand-carts. Even larger barrel organs were to be found in churches, dance halls, ice rinks, concert halls, stately homes and, of course, at fairs. In the 19th century tens of thousands of barrel organs were constructed and, in the Black Forest in south-west Germany, towns were given over to their manufacture. It is sad that so few have survived and those that remain are now in the hands of museums, for example, the St. Albans and the Northleach Museums of Mechanical Music or in the hands of private collectors. There is also an active British Organ Grinder's Association which organises organ grinding meets all over the country. At the very end of the 19th century, barrel organs were largely supplanted by organs using continuous strips of perforated folding cardboard, known as book organs, and in recent times by perforated paper roll music.

Barrel organs suffer from one fundamental disadvantage and that is that the playing time is governed by the diameter of the barrel. For example, a tune pinned to a barrel having a diameter of 95mm will have a circumference of 300mm and at a peripheral speed of 10mm/ s could have a playing time of about 30 seconds. On the smallest organs, between 5 and 8 different tunes could be pinned. One reads that in the heyday of the organ grinder and his monkey, the same short tune might be played over and over again until he was either paid to move on or encouraged to do so by a chamber-pot full of slops. In some countries, organ grinders had to be licensed. Book organs on the other hand could play a repertoire of music as long as the book or books were easily changed.

General Arrangement

Before embarking on the detailed construction of a barrel organ, a brief description of what it consists of and how it works is appropriate. Figure 1 shows the general layout of a small organ and note that the back of the organ faces the grinder who turns the winding handle. There are 4 main parts: -

1: The wind-chest with its valves, pipe rack and pipes.
2: The key frame and action parts.
3: The bellows and air reservoir and reciprocating mechanism.
4: The removable barrel, the whole fitted into a frame.

Pins and staples let into the surface of the barrel determine the music to be played. The barrel is a wooden cylinder mounted in trunnions, the shaft being extended at one end for the drive pinion and tune changing mechanism. The tunes are set in the barrel by pins for short notes and by staples or bridges for sustained notes, made from flat section brass wire. The barrel in its trunnions is supported by a wooden carrier, which can slide in guide rails transversely across the organ frame. This allows the barrel to be changed or permits lateral positioning in order to play different tunes pinned on the barrel. Grooves in the stud at one end of the barrel shaft correspond with the number of tunes and the pitch or lateral spacing of the sets of pins making up a tune. The stud protrudes through the right hand side of the organ case where it can be locked into a tune position by a pivoted knife, which engages in one of the grooves.

As the barrel rotates, so the pins and bridges cause metal tipped keys to be raised. The keys are contained in and pivot within a tracker frame held above the barrel and supported at either end by the sides of the case. The keys are kept at the correct lateral spacing by means of a slotted brass strip or comb. The other end of each key operates a thin wooden rod called a sticker, which acts on a spring-loaded pallet valve in the wind chest.

The whole key frame can be lifted in toto by a cam to enable the keys to clear the pins when moving the barrel laterally. A mechanical interlock on the right hand end of the case prevents the barrel from being moved for tune changing without lifting the keys clear of the pins and bridges. In addition, the key frame is provided with a number of adjusting screws so

The rear view of the barrel organ showing the pinned drum and bellows.

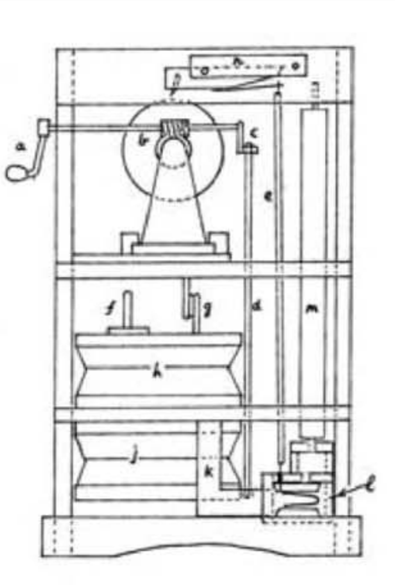


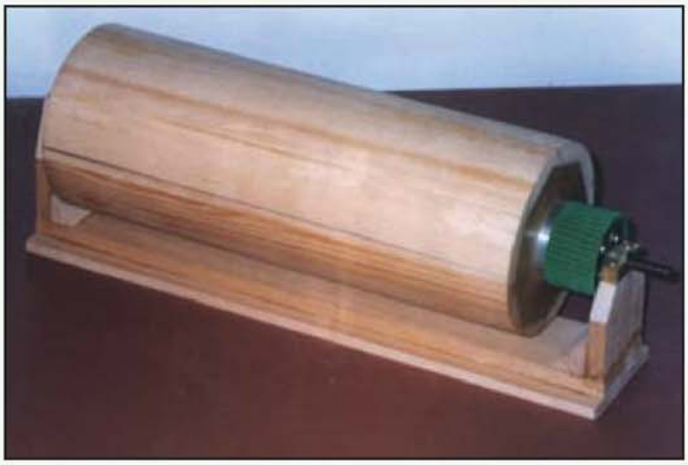
Figure 1 General Arrangement

a. winding handle	h. reservoir
b. barrel	j. bellows
c. crank	k. air duct
d. connecting rod	l. windchest
e. sticker	m. organ pipes
f. relief valve	n. tracker bar
g. reservoir pressure spring	

©

that the keys can track correctly.

Next, the pipe speaking components. Air from the reservoir is fed through a duct to the wind-chest. A short wire extension on the bottom end of each sticker is led through a close fitting hole in the wind-chest to rest on each spring loaded pallet valve.



The turned wooden barrel was designed to be accommodated ona Myford ML10 lathe. It is shown before 'noting' and pinning.

When a key tip is lifted by a barrel pin or staple the other end of the key is depressed with its sticker, which in turn opens the pallet valve uncovering a wind-way leading to a pipe set in the pipe rack. This causes the chosen pipe to speak. Pipes for barrel organs were made either of wood or metal and could be either open ended or stopped.

Stopped pipes sound an octave lower than open pipes and hence, for the same note, are half the length of an open pipe. Hence when space is limited, stopped pipes predominate in small organs. However open pipes tend to sound brighter than stopped pipes because both odd and even harmonics are present.

A barrel organ requires wind at a very modest pressure (say 2 to 3 inches water gauge) and this is provided by a set of bellows, either single or double acting feeders or rocking feeders, pumping air into a reservoir using flap valves. The pressure in the reservoir is usually regulated and maintained by springs or lead weights. The feeders are driven by reciprocators or connecting rods connected to a crankshaft turned by a handle. Turning the handle has two functions - firstly it turns a worm on the crankshaft meshing with a pinion on the end of the barrel causing the barrel to turn slowly and secondly, one or more cranks on the crankshaft move the feeders up and down forcing air into the reservoir.

The left hand view of the barrel organ. timber is the main structural material.

Design

The intention was to design and construct a small barrel organ, which could demonstrate the principles of operation. Small barrel organs had anywhere between eight and twenty-nine keys having up to two diatonic scales (i.e. scales involving only those notes proper to the chosen key) supplemented possibly by two or three bass notes. I decided to limit my design to twelve keys in the scale of C (i.e. just the white notes on a piano keyboard) due to my limited knowledge of music and knowing that I could find a number of tunes in C in very elementary music books. Allowing 20mm spacing between keys meant that the barrel should be about 260mm long to allow for tune changing. Twenty millimetre spacing would permit a very conservative five tracks each 2mm wide each separated by 2mm. Eighteenth century organ builders often used to cram eight tracks into 20 millimetres. Since the barrel had to be turned in my Myford ML10 lathe, the height over the cross-slide limited the diameter of the barrel to about 95mm. Having set these parameters, I proceeded to the drawing board and sketched out the dimensions of the principle elements. Please note that in this article, I have provided just some of the dimensions as a guide since few are critical and with the hindsight of my limited experience, the design could be improved. Also I make no apologies for mixing metric and imperial units - sometimes one is more convenient than the other!

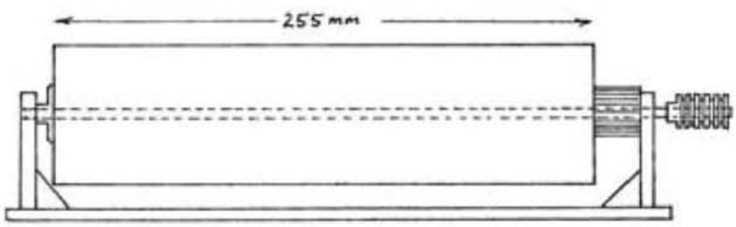


Figure 2 Barrel, side view

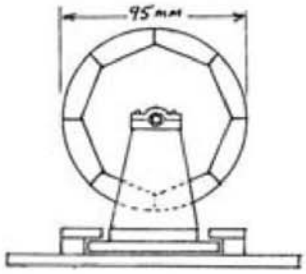


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Figure 3 Barrel, end view

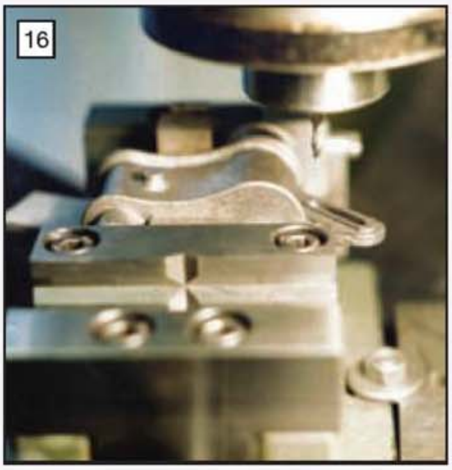
Barrel

I began with the barrel, see **fig 2**, since I thought this might present a small challenge in turning accurately something quite large for an ML10 lathe. Barrels were traditionally made from poplar planks glued to oak octagonal end pieces as illustrated in **fig 3**. Poplar was not available so I used open grained softwood free from knots and carefully shaped to leave no gaps in the joins. The planks were glued to the octagonal end pieces, which were cut from 20mm thick MDF, the whole turning on a 1/4in. dia. shaft. An aluminium alloy flange about 40mm in diameter was turned and screwed to one end piece and fixed to the shaft by a set screw. The barrel was turned in the lathe to the maximum diameter limited by the cross-slide. To the other end of the barrel, I screwed a gang of four, Module 1, 40 tooth plastic gears each 5mm thick, since the gear needs to be 20mm thick. These will in due course mesh with a single start plastic worm fixed to the crankshaft.

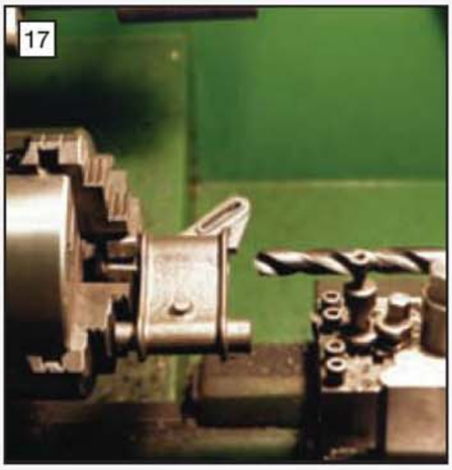
Why did I choose 40 tooth gears? Well, they happened to be in stock and they turned out to be about right for a small diameter barrel and low capacity bellows which needed to be pumped quite fast. In these circumstances, a handle turning rate of 100 to 120 turns per minute is appropriate. One hundred turns per minute is 0.6 seconds per turn and, with a 40:1 ratio, the barrel will take twenty-four seconds to rotate through one revolution.

The circumference of the barrel is 300 mm so each second the periphery will travel 12.5 millimetres. If the winding handle speed is 120 turns per minute, then the barrel will take 20 seconds to rotate and the peripheral speed will be 15mm per second. The references suggest that a bar of march time (4/4) music takes typically one second so there will be room on the barrel for 20 to 24 bars of music in each track. Having completed the barrel, this was then mounted in trunnions using a brass bush bearing at one end and a split bush at the other set in a hardwood carrier.

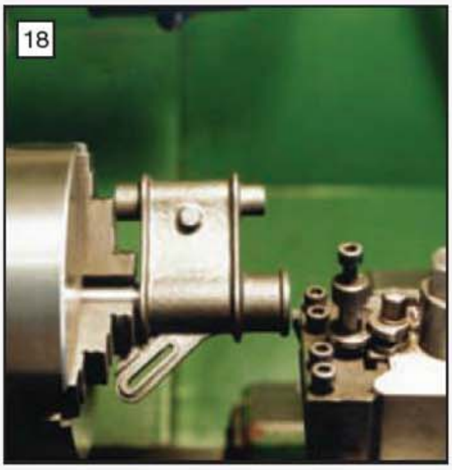
●*To be continued.*



Machining the slot in the back of the drill head casting using a slot drill.



Drilling the hole in the drill head for the main column prior to reaming or boring to size.



Facing the opposite end of the drill head with the work mounted on an expanding arbor.

BUILDING A STUART MODELS PILLAR DRILL

Anthony Mount now describes part 24, the drill head for this model of an industrial pillar drill.

●*Part III continued from page 147 (M.E. 4279, 4 August 2006)*

The next casting to be machined is the drill head. This is a most difficult casting to hold, as there is hardly a straight line in it. The first machining operation after cleaning up the casting is to machine the slot at the back. As you can see from **photo 16** the head is clamped in the machine vice on the vertical milling machine. Packing is used to clear the bosses and packing underneath to level the casting, and the vice is set over at an angle to line the slot up with the axis of the table.

Pick up the edge of the slot with an edge finder and locate the centre of the slot. Then drill through each end of the slot with an 1/8in. dia. drill, and at the same time set the stops on the table. Change from the drill to an 1/8in. slot drill and machine the slot in a series of shallow cuts. Small slot drills are not that robust and with deep cuts could wander off line and even break. After machining the slot change to a larger end mill and face off both faces of the slot.

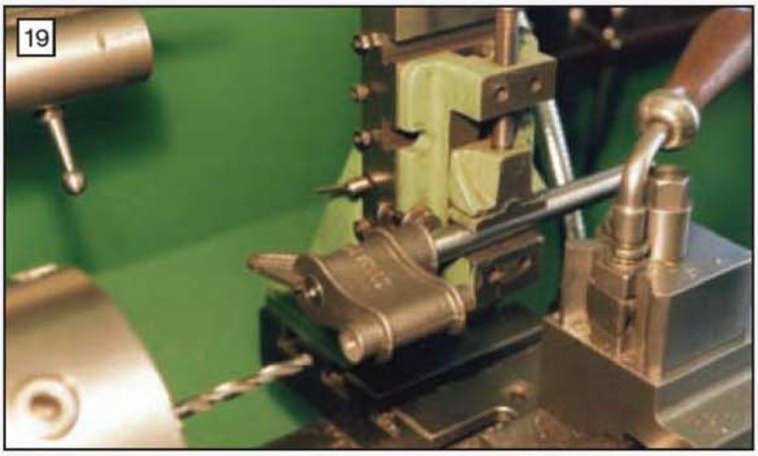
The head casting presents quite a few machining problems and **photo 17** shows the first set up in the lathe for drilling the column bore. All four jaws will need mild steel packing between them and the boss to clear the bead. Take your time setting it up and double-check that all is in line and running true.

Use a slow speed as with this amount of offset the set up is unbalanced and a fast speed will cause a lot of vibration. Centre deeply, drill right through and open out in stages finishing to size with a reamer or boring tool. The chuck can be changed to a self-centring one and the head mounted on the expanding arbor for facing off the other end, see **photo 18**.

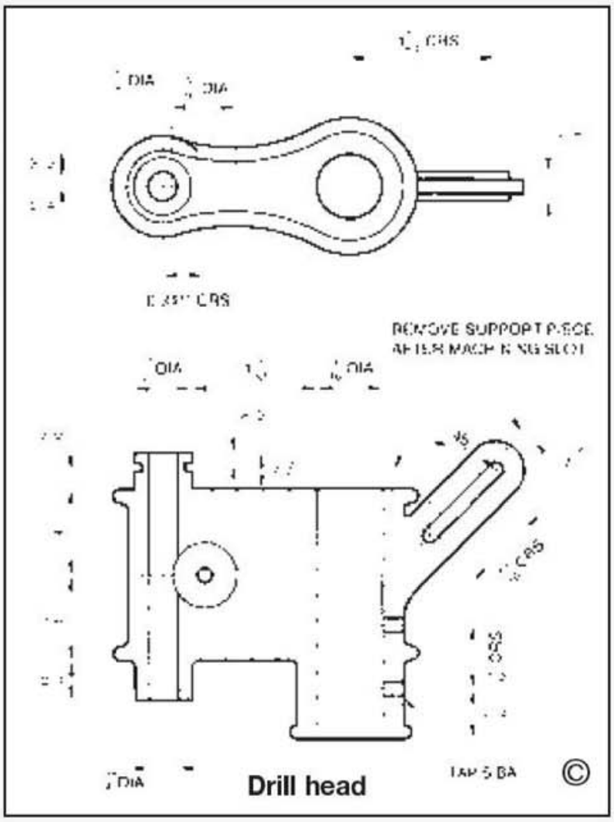
You can see from **photo 19** that the head was now clamped in the machine vice of the vertical slide by the expanding arbor for drilling the hole for the spindle. Be very careful in setting up, check that the machine vice is parallel both ways to the lathe bed. Use a centre in the headstock to pick up the centre of the column hole and use co-ordinates to position the spindle hole. This can be drilled through with an undersize drill and then opened out to just undersize and finished with a machine reamer.

I used these set ups to try and avoid jig making. But should I make another drill I will do this part of the job another way. The problem is the shape of the head with no straight lines. To overcome this I will make a former from a hard piece of wood hollowed out to fit around the body like a cradle. The underside of the cradle will of course be flat. This will be mounted on packing on the lathe cross slide with the centres of the holes on the centre line of the lathe.

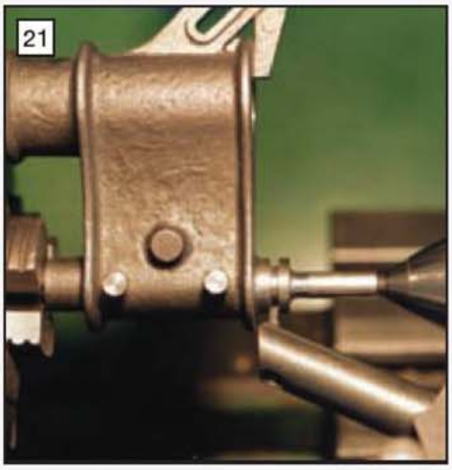
A strap clamp will go across the top of the casting and be held down to the cross slide with



The set-up used for drilling the hole for the spindle in the drill head casting. The casting is located on an expanding mandrel held in a vice.



Turning the pulley boss. Lack of space required a boring tool to be used.



The groove for the pulley set screw was turned using a grooving tool in a boring bar.

Machining the counter bore for the lever handle spindle with an end mill.

T-bolts and nuts. Then the holes can be drilled and reamed with drills in the lathe chuck, the centres obtained by co-ordinates. A similar set up to that used for the inside cylinders of a steam locomotive. It will also be possible to machine the boss for the pulley by using a boring head with an inside facing tool.

The groove in the boss presents another problem, to be able to get at this with a grooving tool and avoid the pulley bracket involved mounting the head by a 1/4in. diameter mandrel one end in the chuck, the other supported by a tailstock centre, as seen in **photo 20** where a boring tool is being used to turn the pulley boss to diameter.

Notice also that instead of using an expanding arbor I drilled and tapped a couple of holes in the head and fixed it to the column with some hexagon headed bolts. The holes can be filled with epoxy car body filler and will never be seen once the head is painted.

It was now possible to get at the boss with some cranked tools and a set over boring tool. Do not attempt work on this boss without tailstock support. **Photograph 21** shows a boring tool set over at an angle with a short parting type tool being used to put in the groove for the pulley set screw.

The head was now clamped in the machine vice of the vertical milling machine. Packing is needed at the end to clear the boss and packing underneath to level the head. A length of 1/4in. dia. rod was placed in the spindle hole and this was used with an edge finder to locate the position of the spindle centre line. Then, with co-ordinates, the position of the 1/8in. dia. hole was located on the gear spindle boss. You really need to position this accurately as the rack and pinion should only have a 0.001in. clearance. Hopefully the hole will come near the centre of the boss.

Turn over the casting and reset with everything level, pick up the centre of the 1/8in. dia. hole and form the counter bore for the lever handle spindle. Start with a 1/4in. drill then open out with first a 7/16in. then a 1/2in. then a 9/16in. end mill, this set up is seen in **photo 22**. Run these end mills at a slow speed to avoid chatter when using them as counter bores.

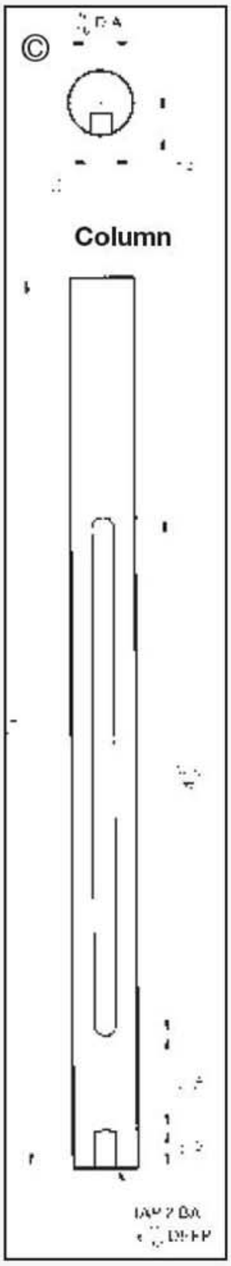
The reinforcing to the jockey pulley slot can now be sawn away and the casting tidied up ready for painting, after which it should look like **photo 23**.

Column (part 2)

The column is a fairly simple turning job. The material is supplied as 5/8in. dia. mild steel bar. So, the first job is to centre the end in the lathe, give tailstock support and to turn it down to 9/16in. diameter. Use a fine auto feed for a good finish.

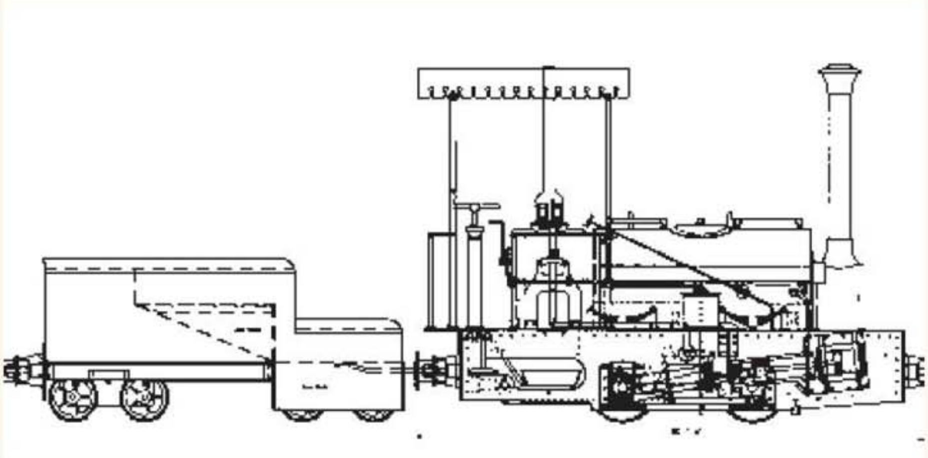
Part off and bring to length. Drill and tap the end, the drawing shows 2BA but I used M5 as all my Allen screws are metric and easier and cheaper to obtain. Clamp horizontally in the machine vice and with the aid of co-ordinates locate the ends of the rack slot. Set the table stops and drill a 3/16in. dia. hole each end. Join the holes with a 3/16in. dia. slot drill to a depth of 3/16in, as shown in photograph 24. Do not use an end mill as they always cut oversize in this situation, except that is for three lipped end mills, these will also cut a slot to size.

●*To be continued.*



The finished drill head casting after painting. This is possibly the most demanding part required for the model.

Machining the rack slot in the column using the vertical milling machine.



D.A.G. Brown and Mark Smithers make a welcome return to our pages to bring readers up to date with the *Anna* build programme.

●*Part XXV continued from page 90 (M.E. 4265, 20 January 2006)*

ANNA
A MANNING WARDLE LOCOMOTIVE FOR 7 1/4in. GAUGE

Although we finished the main run of the series on this fascinating locomotive at the beginning of the year, liaison with interested parties has revealed support for providing some further notes on construction, in particular making mention of some of the more unusual or demanding manufacturing techniques which have evolved during my construction of the prototype. As you will be aware if you followed the series, I have been following the drawings myself and the original example is now well developed and I am ahead of the 'competition'!

Out in the wide world there are at least a dozen examples being made, judging from the orders for components which have left my workshop. I have also been amazed that there are even a few people who think that aspects of the design have something to offer and have incorporated various components into completely different models. Thus we have a *Tinkerbell* with *Anna* buffers, the odd narrow gauge model with our couplings and several examples where people have bought springs for safety valves and driver's brake valves.

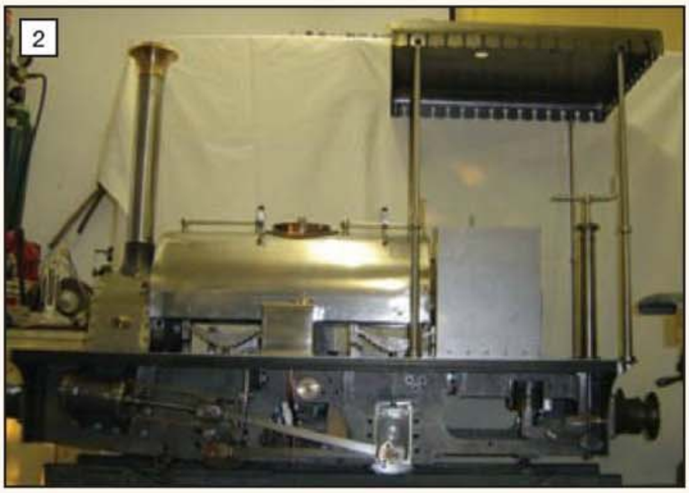
I do find this cross-fertilisation very interesting and it surely proves that many people read the articles even when they have no direct interest in constructing the model being described. Armed with my digital camera I have so far captured well over 100 of the most interesting or demanding operations in the workshop and shall now use them selectively.

Saddle tank

As I originally promised, the body of the tank is available as four laser-cut pieces in 1mm 3Cr12 material, my original advice having been to have it TIG welded. In the event, my friendly supply of welding skill shied away from the job, commenting that it would distort unacceptably. That led me to consider conventional joining techniques using silver solder. I do have oxy-acetylene in the workshop and that enables me to perform short runs with relatively low heat input, thereby minimising any distortion which would occur if a large area of sheet metal were brought up to high temperature at one go. The result has proved the soundness of this method; the area of discolouration near the joints was limited to about 1/2in. all round.

Now let us go back to the original sheets as delivered. Look at **photo 1**: the main panel of the tank includes the whole sweep around the visible surface, going right round under the tank bottom surface, which is to be supported by two props just in front of the locomotive cab. All of these details are on the drawings. The seven tabs are clearly visible at each end, the extreme ones being located in the bottom surfaces, which have eventually to be bent into shape through 90 degrees. The laser layout is made to accommodate a sharp bend, which can best be achieved by cutting a half-depth groove along the inside of the bend. This groove can clearly be seen in the picture, located with its middle 0.025in. inside the finished width of the tank bottom. Here is how that can be achieved. Clamp the sheet firmly to the milling machine table, probably being prepared to do the cut in two stages, a foot at a time. Make sure that the working edge of the panel is precisely parallel with the machine axis and clamp say a length of gauge plate touching the edge of the part, in such a way that subsequent fixings are all identically located. This should be arranged using a dial gauge to register nil deflection as the machine slide is moved. Next, locate the edge of the job under the spindle axis and move the table 1.586in. in the Y direction. Using a ball nosed cutter of say 2.5mm. diameter, set it just to touch the work surface. If the work has been firmly clamped to the machine table, with a length of strip material to keep it pressed flat into place, you should have a uniform witness right along the length of the cut. Now form the groove to half sheet depth (0.020in.), possibly requiring two cuts for a good finish. It is this pair of grooves which is clearly visible in the picture. I must here register my thanks to Professor Peter Thomas for his sound advice on perfecting this

Laser cut tank sheet with 0.020in. deep grooves for bending and guide lines marked for rolling.



A recent photograph of the assembly.

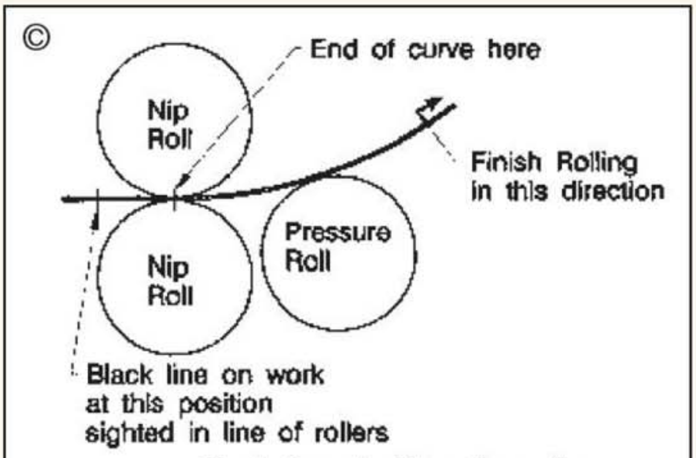


Fig 1. Layout of bending rolls

Close-up of 2mm thick end panel stuck onto the tank end. Note also the fabricated 'rolled angle iron' joining the tank to the smokebox. Screws inside the tank are capped with dome headed nuts and fibre washers.

technique, which he has fostered to good effect at Polly Models.

One of the things which is not quite predictable is the precise dimension which will be achieved after bending the right angle. Nominally, if the cut is made at a certain location, you would expect the outside of the fold to lie one half of a sheet thickness outside that line (i.e. 0.020in.). This is not quite true, however, since the material does not fold in a really sharp angle. From tests which I carried out on scrap material, it is fair to assume that the outside edge of the bent product lies some 0.005in. outside the theoretical line.

You will also note the marking of two pairs of black lines, drawn by a magic marker as a guide to plate rolling. All the holes have been cut by the laser and their edges cleaned up so that no burrs would have to pass through the rollers. I have also taken the precaution of marking the inside surface of the tank to avoid being a clown and producing a left handed locomotive! Seriously, think it through before starting operations. I rolled the sheet upwards in the rollers, so that the finished form was a U-shape with the legs pointing to the ceiling. The inner pair of black lines represents the nominal ends of the half circle to be rolled, and the outer two are drawn 1in. outside them, merely to act as sighters for the outside diameters of the bending rolls (2in. dia. in my case).

The bending rolls have a pair of pinch rollers, (see **fig 1**) say nearest to the operator, with a third (pressure) roller positioned behind the lower pinch roller, whose duty it is to apply pressure to the lower surface of the job. Place the job in the roll stack and just close the rollers, so that they lightly grip the 1mm. material. Now raise the pressure roller so that it just starts to apply pressure to the bottom of the sheet and turn the mangle back and forth, being careful to stop when the outer black line indicates that the end of the curve has arrived in the pinch. Note that the 'loose' end of the sheet has no such clear definition, and indeed do not attempt to go near the other end of the curve. When you have achieved a modicum of curvature, say 60deg., loosen the jacking screws at each end of the pressure roll by a known number of turns; reverse the job in the pinch rolls, restore the pressure roll to its previous position, and repeat the rolling procedure as far as the black mark on the other end of the job.

Now take that end of the curve a bit further and repeat the rolling sequence to both black marks in turn, a little at a time, before achieving the full 180deg. of the tank top. If you were to attempt to roll that far in one go, or without repeated reversals in the rollers, the result would be quite grotesque, more of a parabola than a semi-circle. You should be able to get to within about 2deg. of the 180deg. required, from which you can easily spring five of the tabs into their slots in the 1mm end panels. The other two tabs are on the short sections, which now have to be bent at 90deg. to the main body of the tank. Clamp this short section under a rigid bar near the edge of the work bench and prise the main bulk of the body upwards, using no more than elbow grease and possibly a scantling of timber to achieve the 90deg. bend. At this juncture I found that all seven tabs on each end of the tank fitted perfectly into their slots and they could be lightly rivetted over to keep them in place for the next operation.

Of course, there is another pattern of bending rolls, in which the three rollers are laid out in the form of a Δ, but with this pattern it is not so easy to achieve a precise curve up to a definite point. With the recommended layout it is easy to finish a curve at the extreme edge of a piece of metal, since the rolling process takes place as the material is fed through the pinch point (moving from left to right in fig 1.) My own preference in the smaller size of rolls is for the George Thomas design, an example of which sits ready in my workshop, whilst for the larger jobs our local society has a set of 3ft. long Edwards rolls, which have been very common for years in sheet metal and panel beating shops all over the country.

Before discussing the silver soldering operation, just note the string of slots in an elliptical shape in the middle of the tank body sheet. These can now be joined up, by brute force from a miniature disc grinder, to form the filler hole in the top of the tank. Had the whole ellipse been cut by the laser, the sheet would not have rolled truly into a semi-circle. Finish the edge of the large hole by filing.

Silver soldering

With all fourteen of the tabs safely in their slots, you will find that you have access to the inside of the joints between body and end panels. Attack these in short sections only, allowing cooling to take place before resuming on an adjoining section. Tackle only say 2in. at a time, and you may have to pickle and re-flux for the overlying runs. Success will best be achieved if you limit the heat input to a minimum; as I stated earlier, I managed to avoid heat travelling more than 1/2in. from the edges.

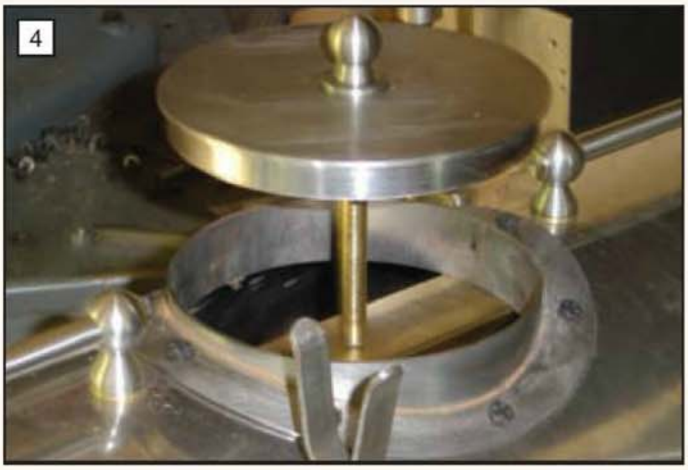
Now we come to the area where distortion is likely to cause the most trouble, namely fixing the bottom panel into the main section. Rolling is quite straightforward, going all the way to each end of the metal; there is one tab on each end, which mates with its slot in the end panel of the tank. Roll it slightly less than required, so that it is a tight fit between the bottom edges of the tank body. The bottom section protrudes through by a nominal 5/16in., so that the joint may be soldered on the outside corner, all the way round, where it is quite invisible to all save Dennis Monk with his confounded inspection mirror. You must start by tacking at about 2 1/2in. intervals, from the tank centre line outwards, securely clamping the bits together near every joint, following up with the bottom curved joints between the tank bottom and the end panels. I cannot stress too much the importance of taking it in short bursts.

When the joints are completed, you can remove the 5/16in. surplus all round with an angle grinder. Any minor damage caused by this process can be disguised with filler, as happens in the best body shops!

Dummy end panels

From the drawing you will see that a 2mm dummy panel is fitted to each end of the tank, 1/8in. smaller all round than the main end shape, thus emulating the original construction in which the ends were flush rivetted to rolled iron angles, leaving some of the angle visible all round. The silver soldering process had caused a slight attack of the 'Norah Battys' in the 1mm end panels, with the effect that they were slightly cockled. The laser had cut matching 5/16in. dia. fixing holes both in the ends and the dummy panels. Araldite was applied to the dummies and the whole lot clamped up over night. The result is most pleasing, as can be seen from the close-up shot of the end detail, see **photo 3**.

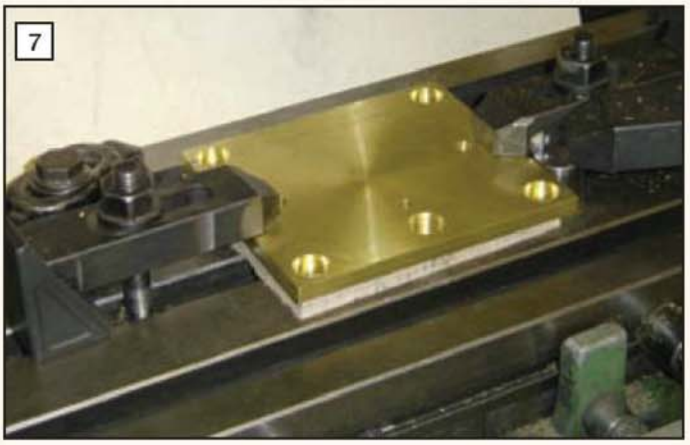
The rest of the components relating to the tank are quite simple. The simulated rolled angle at the front is fabricated from two pieces of 3 and 4mm mild steel, already drilled and shaped to miss the chimney base. When it comes to the filler cap, again straightforward fabrication, but I have a thing about stray filler caps and helpful small boys who like to fill one's tank whenever stationary. The chances of a cap falling onto paint work are quite high, so here is my solution: a 4 1/2in. long stalk is screwed under the filler cap centre line, with a large washer bolted to its bottom end. Set 1/2in. from the washer, an O-ring 'clicks' the cap into place as it is lifted through its retaining hole in a piece of flat stock; this in



The filler cap is supported by a brass stalk which passes through a flat section bolted under two of the flange bolts. An O-ring keeps it in the air.

Cutting grooves in the sandbox using a ball nosed cutter. A scrap of steel plate keeps the job flat on the table.

After 'running round' the job, the stops have been fitted to the table. Note the MDF pad for security and protection.



Drilling operations following milling the small locating grooves. All components register against the stops.

turn is bolted under two of the screws which attach the filler assembly to the tank body. In **photo 4**, which captures the lid assembly, the curved flange can also be seen; its upstand is simply rolled and it is silver-soldered into the main piece. This, whose plan view is a circle, starts life (before rolling) as an ellipse, with its eight holes on an elliptical pitch (but almost a circle) whose major and minor axes are almost the same. That was an easy job for the laser!

Other right angle bends

There are several other pieces which benefit from the right angle half thickness treatment described above: the cab sides (or modesty panels) are a case in point. The left assembly was arranged to fit around pieces of $^{3}/_{4}$in. angle, which were coordinate drilled on both surfaces. With the four 0.020in. slots milled, the angles were rivetted before bending and it was pleasing to discover that the angles fitted snugly into their corresponding holes in the footplate, confirming that the arithmetic was correct for the plate sizing. The right hand panel is just a simple right angle bend to keep the breeze out of the driver's Y-fronts. Having bent the sheet, there is perhaps the need for some stiffening. Run flux along the bend and make a slight fillet of silver solder. This works wonders.

Sanding Gear

The two sanders sitting on the footplates are a hallmark of Manning Wardle and they are drawn out to represent the prototype form. In the main run of these articles I rather glossed over their manufacture, but in the event there were some interesting object lessons in their construction. The main body sides were cut by the laser, with four positions of the corners to be folded marked by means of laser spots. So, as in the case of the cab sides, they were milled to half depth while clamped on the milling machine table (see **photo 5**).

After bending to a rectangular section, the joint was silver soldered in the middle of the back, where it is completely out of view.

For the top and bottom of the sanders I had acquired, some years ago, some yellow brass strip which was not quite wide enough to make the said components. So I decided to silver solder a strip on; this I did, having cut the pieces oversize. It was a simple matter to face off the material to correct thickness after fabrication and this made the joints all but invisible. Each of the four pieces was in turn clamped to the table and run around with an end mill, using a scrap of MDF to ensure no movement and to give foot room for the tool. With the job clamped left and right as in **photo 6**, the long edges of the job can be machined; furthermore, if the Y coordinates of the two operations are subtracted from each other and the result halved, this leads simply to a precise definition of the centre line of the job. Now moving the clamps one at a time to a position below the component. It is possible both to cut the piece to length and to determine the other centre line. So we now have the job clamped to the table and we know its centre; I decided to rebate the edges of the bottom plates as shewn in photo 6, so as to leave $^{1}/_{4}$in. height visible after assembly and this was done at the same settings and with the same cutter as the main cuts.

When the last of the four pieces has been machined, clamp a straightedge (of gauge plate) touching the back, the clamps making use of the rear T-slot. A further stop is clamped to the right of the operating area, with its clamp again out of the way. It is now easy to clamp each of the four components in turn for further operations, in the sure knowledge that they will all be registered precisely to the same datum point.

The next operation in all four was to machine a 1.5mm slot all round to a depth of 0.025in., to locate the 1mm sheet metal body. Such an operation is admittedly rather delicate, but the small cutters are available at not too high a cost. The location of these grooves by coordinates is really simple using the datum already set up. Running the machine at top speed, and using a slow feed, parts of one's body may be made to twitch which would normally only be experienced by a cat stalking a pigeon.

The further operations on each pair of end plates are done with the drill chuck fitted, as in **photo 7.** Drilling and tapping the holes as drawn is routine, four for the corner tie bars, two for the bottom clamp screws and so on. You should end up with interchangeable assemblies, not forgetting that the filler holes in the two tops must be mirror imaged!

Looking at **photo 8**, I have added some neat sections of beading around all the top edges. Admittedly they could have been carved out of the solid, by starting with larger slices of

One of the sandboxes in position, shewing the brass beading sweated into place.

material; but what a chore! I decided to make the beadings and to soft solder them in place; the result is good, so here is the quick tip, which is economical in material; we need 8 lengths of beading, say $4\frac{3}{4}$in. long to allow for the mitres. Start with a 6in. piece of brass $\frac{3}{8}$in. diameter. Drill through $\frac{9}{32}$in. (attacking both ends?). Support on a parallel in the machine vice, or clamp directly at each end to the machine table and mill to a depth of about 0.320in. with a $\frac{1}{4}$in. dia. slot drill to produce a slot of $4\frac{3}{4}$in. length with a bit unmachined at both ends. You can now remove the two ends and you are left with three sections of beading just joined at the hip. Repeat for three sets.

Gentle persuasion after cutting to length will cause them to snap off cleanly. Finish with emery, mitre the corners and apply using solder paste. I did specify a $\frac{1}{4}$in. slot drill; this must be sharp, but it only has to remove the amount of material which the $\frac{9}{32}$in. dia. drill has left behind; furthermore the void left by the drill down the middle of each flat certainly helps with the flowing of the soft solder. If you cannot understand what I have just written, **fig. 2** should assist.

One word of warning about solder paint: it is a mixture of solder particles and killed spirits (zinc chloride), which is a fierce flux. It does help the joint to make easily, but it has a pernicious after burn! If you leave traces of it on the job without washing it off, it will rust anything in sight, as I well know to my cost.

One final feature of the sandboxes is their filler caps, drawn out as a loose piece of metal which fits over a length of tube which in turn is applied to the top panel. One other machining photograph (**photo 9**) is a view of the top panel being bored out for a short length of $1\frac{1}{4}$in. dia. brass tube. This tube is merely Loctited into the hole to avoid unnecessary heating of the material. The lid is turned to be a good fit over the tubes, which will certainly keep out the rain, but again my anxiety about small inquisitive fingers shewed through, with the desire to make them fast against straying.

The hole for the filler cap is shown being bored in the top of the sander.

My solution is to fix a short length of picture-hanging chain to the underside of the filler cap and to apply a $1\frac{3}{4}$in. length of steel rod to the other end of the chain, making it rather like my father's Belcher chain's buttonhole restraint, which I still wear across my corporation with my dress suit. If the rod is fed into the neck of the sander it cannot be readily pulled out, so the lid should not get lost. When I mentioned this small feature to Mark, he said *"That is exactly what Manning Wardle did"* and could produce old photographic evidence.

A load of balls

The superstructure of the locomotive is embellished by a fair number of balls, in particular those visible in photo 4 and 8. It is worth making a careful job of these; I employ a Radford ball cutting tool, which these days is in the armoury of Hemmingway's designs. It is an excellent concept, the layout enabling it to cut quite close up to the chuck. There are, however, two pitfalls which should be avoided, so as to ensure plain sailing. The first is to work out the exact length of the shoulder to be formed into a section of a sphere, so that no undercutting will be required. The second is to remember that the tool cannot take large cuts, so do not try anything greater than 0.020 inch. The final cut should be taken with a very slow feed, by pulling the lever around the fulcrum very slowly, with the lathe rotating at about half the speed, which you would use for normal turning operations. To illustrate what I mean about the correct shoulder length, consider a ball end on a $\frac{3}{4}$in. dia. bar on a stalk which is turned down to $\frac{3}{8}$in. dia. locally for blending with the end of the ball.

The hemisphere at the tailstock end of the job is obviously 0.375in. long. At the inboard end, the circumference of the sphere blends with the half diameter shoulder at a point which is to the left of the centre of the sphere by an amount:

$$\sqrt{[(3/8)^2 - (3/16)^2]} = 0.324 \text{ in.}$$

So the overall length of the shoulder before cutting the spherical shape is 0.699 inch. In practice, start with it a few thou. shorter than this, merely to allow for a small radius on the cutting tip of the radiusing tool. Before starting to cut, make sure that the tool point passes through the axis of the lathe. Bring down the tool to touch the outside diameter of the stock in the chuck; this will give you the eventual finishing position for the final cut. Rack the tool post towards the tailstock, rotate the tool through 90deg., so that it is on the lathe centre line, and bring up the tool just to touch the job. Again this represents the finishing point of the cutting process. Wind back the tool until it just makes a cut and start the metal removal. It does help if the edges of the job have already been rough machined, so as to avoid having to make too many fine cuts.

●*To be continued.*

Drawings, castings and laser cut components for this locomotive are available from the designers. Contact: D. A. G. Brown; tel: 01780-753162; email: dag.brown@btopenworld.com or Mark Smithers; tel: 01904 794430; email: marks_northall.yorks@tiscali.co.uk

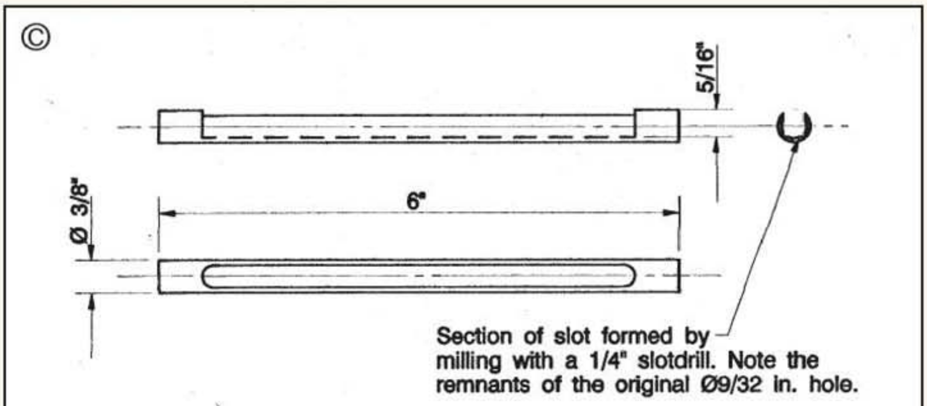


Fig 2. Slot milling operation to form 3 sections of beading

A SYNCHRONOME CLOCK

Patrick Williams
in Germany, describes a fascinating timepiece he has inherited that was built by his uncle in 1946.

Many years ago when my brother David and I were only boys we went to spend a week with our Uncle Doug and Aunt Doreen in their pre-fab which was in Corsham, near Bath. Uncle Doug had procured the material to make a clock and, pre-fabs being small and space at a premium, he was checking some parts laid out on the floor. I think he was looking at the main frame, and other parts were scattered around. The clock (**photo 1**) used the Synchronome system, where an electrical impulse was created every half a minute, and was used in railway stations as a master clock to drive all the clocks in the station. The clock's pendulum had a hook on it to pull a ratchet wheel one tooth at a time, and every half minute an extra deep tooth allowed the hook to drop and make an electrical contact which gave a push to the pendulum and an impulse to all other clocks. Now this hook was subject to much wear and to offset this was made from a ruby, see **photo 2**, which Doug had carefully wrapped in a scrap of tissue paper. Doreen came in from the kitchen and saw this scrap of paper on the floor, did what any housewife would do and picked it up and threw it on the fire! Now I can't remember whether Doug managed to rescue it straight away or rake it from the ashes the next day, in any case rubies are made of tough stuff and no harm was done, but we did have a few moments of excitement. I wonder if that was the beginning of my interest in clocks and things mechanical?

Years later Douglas was looking for a new glass and bezel and I sent him a copy of some pages from a SELVA catalogue, a mail order firm in Germany providing clock parts but as it turned out none were suitable.

The clock remained for many years at his home and, upon his sad demise, Doreen let me know as I had always shown an interest in the clock. Uncle Douglas had wanted me to have it, knowing it would be in the hands of an engineer who would be keen on keeping the clock running. Therefore, during our English summer holiday in 2004, we called to see Doreen at Wimborne, Dorset where she had moved to be with her daughter and son-in-law and collected the clock to take it back to Cologne. While in Wimborne Doreen also gave us some documentation for the clock, and also told us the story of the case's construction. Douglas had the clock hanging free on the wall in his home but the swinging pendulum was too fascinating for children, who couldn't keep their fingers off, so he decided to make a case. Around this time he visited my father, his brother, in Bristol, who was in the process of replacing an old-fashioned wooden fireplace and its mantelpiece with a modern tiled one. Douglas saw that the fireplace surround would produce some useful lengths of oak boards including mouldings and claimed the wood before it could be discarded. The case he made is clearly shown in the photographs, suits the clock beautifully with its glass door to show the mechanism, see **photos 3** and **4**, and is not dissimilar to other synchronome clocks. It is intriguing to think that somewhere on the clock is the hole which took the hook upon which I hung my Christmas stocking when a little boy!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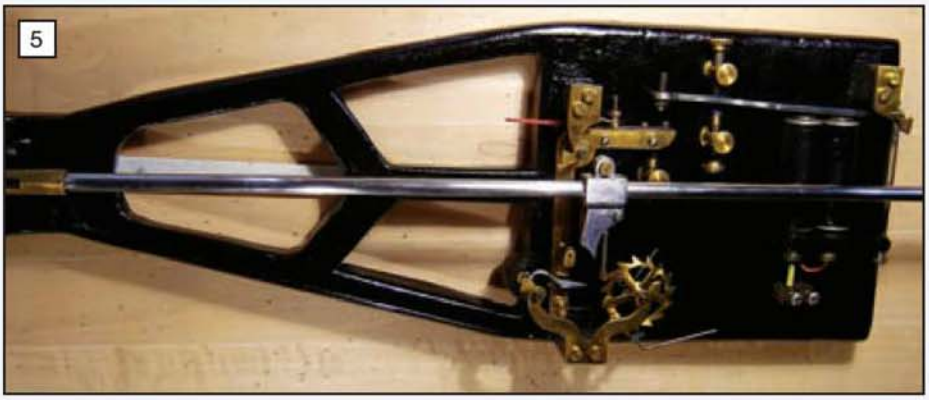
Clock description

Around 1946, Douglas Williams sent for a kit of parts for a synchronome clock from the Synchronome Company of the Abbey Electric Clock Works, Woodside Place, Alperton Middlesex, and although Doug was in the inspection department of the Bristol Aeroplane Company he managed to put the clock together even though a few of the parts, like the pendulum for instance, was probably turned up by friends. The clock was completed and hung on the wall in his home near Bath. Later the clock was given an oak case standing 4ft. 6in. high (137 centimetres) as previously described. Originally made for use with dry batteries it was later provided with a 12-volt transformer and driven from the mains. Photos accompanying this article show the clock in 2005, with the mechanism either in the case or on test (**photo 5**).

With the clock to hand, I set about trying to find more about synchronome clocks and turned to the Internet, where the most useful homepage was that of Barrie's Clock Museum, from this and other sources the principles of the synchronome clock have been gathered and summarised here.



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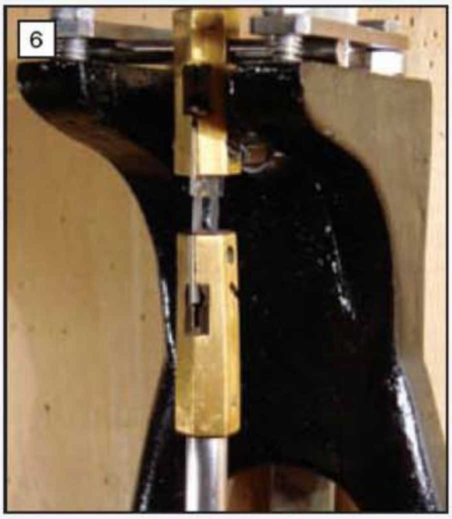

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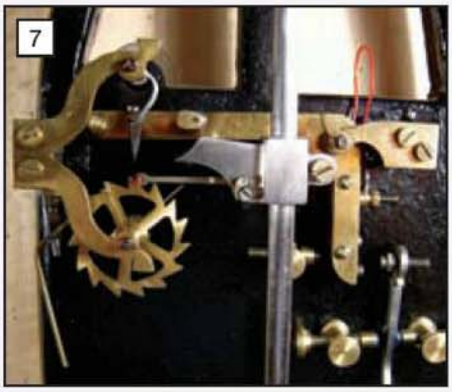

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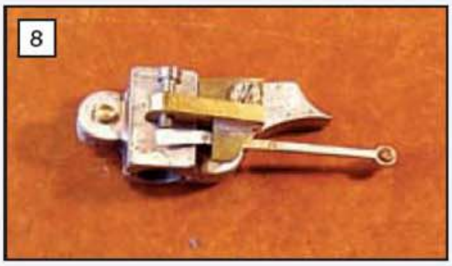

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History of the Synchronome clock

Patented by Hope-Jones in 1907/8, the Synchronome was developed to become one of the most successful master clocks. It is popular with collectors, possibly because the slave dial, which is usually mounted in the top of the case, does not obscure the view of the mechanism.

Mr. Shaw of Sussex, writing in *Model Engineer* of February 1993, claimed it to be a design invented by a mining engineer in the 19th century, was the nearest thing to a free pendulum and was used for the Greenwich time signal pips until the quartz crystal came on to the scene, so it was a system which was successful.

The Synchronome Co. started producing clocks in 1900, and the movement remained virtually unchanged from 1908 until 1962, and in addition, from the 1930s onward the company made castings and parts available to enthusiasts.

The design of the clock seems to be very suitable for someone without access to machine tools (like mining engineers?) as only the count wheel, the pendulum rod and the pendulum weight need machining, even the count wheel can be carved out by hand, which does not affect the accuracy as the design absorbs minor irregularities.

In the Synchronome Company clock design the push on the pendulum is merely the weight of the impulse lever falling every 30 seconds imparting its impulse to the pendulum via a curved surface on a block fixed half way up the pendulum rod, the falling impulse lever causes two electric contacts to meet and the current which is led through two wire coils attracts magnetically a lever which throws the impulse lever back up to its original position ready for the next action. This electric impulse also drives the minute hand forward every half minute.

In the Synchronome clock the wear of the gathering pawl rubbing over the count wheel every second was counteracted by the use of a ruby and this is confirmed in the Synchronome Co. leaflet, in which they refer to the 'gathering jewel' This is the ruby which caused the great excitement in the opening paragraph of this article.

In the Jubilee Clock John Wilding has made his hook from a piece of hardened and tempered spring steel, part of an old hacksaw blade in fact, as John Wilding is well-known for his clockmaking skills it would seem that the jewel is, in fact, not really necessary. If Douglas had known that perhaps the story of the ruby on the fire may have had another ending! On the other hand, the arresting pawl on the Synchronome Co. clock was a glass roller to reduce friction and I can imagine a glass roller of certain dimensions was something which was just not obtainable in England in 1946 so Douglas used a piece of bent brass wire, which does the job just as well, so here he was ahead of the expert clockmakers.

Upon receiving the clock it was found that the stresses of moving house had been too much for the thin metal foil with which the pendulum was suspended and it had broken. With great forethought Douglas had left a spare piece of foil in the bottom of the case so a spare was quickly made, but the constant handling of the pendulum was too much and so it broke again. To ease the problem, and reckoning with the need to remove the pendulum many times while working on the clock, I modified the pendulum suspension parts to take a separate foil enclosed in brass cheeks as described in the *Model Engineer* Jubilee Clock, with the addition of a built-in cross pin which allowed the pendulum to be simply hooked in and out, this is shown in **photo 6**.

Unfortunately during this operation the little comma-shaped lever, shown in **photo 7**, of the mechanism came adrift. It had been soldered on to the end of the gathering pawl shaft, and its purpose was to retain the pawl in the cam block, and by turning the offset head of the adjacent screw the relationship of the ruby to the count wheel could be adjusted. This was not an attempt to simplify the NRA lever, which is a part of factory built clocks, but not installed here, but a method of simplifying the adjustment of the ruby while setting up.

I decided to discard this lever and to provide an alternative system by extending the ruby carrying pawl to the rear and to add to cam block a brass bracket, the purpose of which is to retain the pawl and position a screw to enable fine adjustment of the ruby relation to count wheel. It works fine, and being behind the cam block is virtually invisible. The new bracket is shown in **photo 8**.

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To me an unusual feature of Doug's clock is that the count wheel shaft has conical ends, as seen in **photo 9** of the old count wheel, running in conical bearings, which eliminates the need for the very small drills for the bearings, the taper broaches to open the bearing holes, and the burnishing tools for polishing the shaft ends, the broaches and burnishers being very specialist clockmaker tools. According to Barrie of 'Barrie's Clock Museum' this is a feature which was not part of the original design.

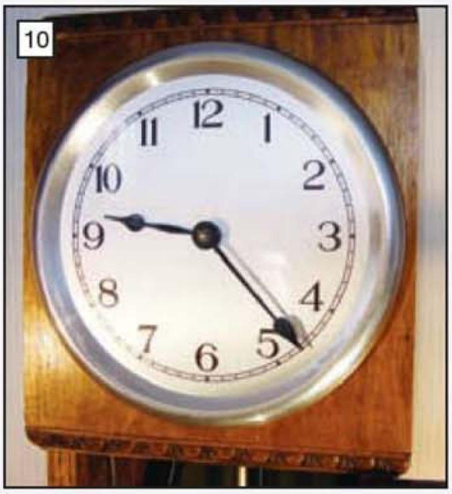
Clocks with similar mechanisms

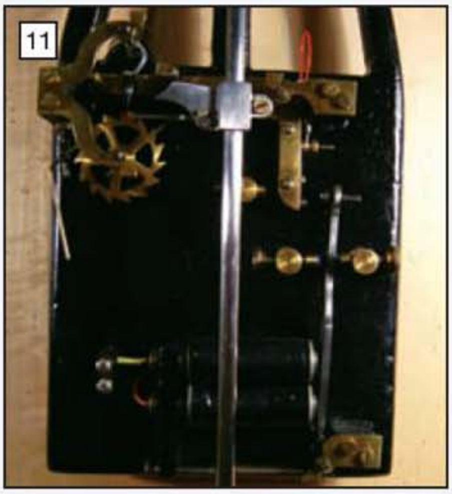
The Hipp method of propulsion uses the decay of the pendulum swing to enable a trigger to engage in instead of clearing a notch situated on one side of a pair of electrical contacts. The over centre action depresses the notched block closing the contacts and the current passes through an electro-magnet situated vertically beneath the pendulum, this attracts the pendulum and increases its arc of swing. The main disadvantage of the system is the difficulty to obtain the magnetic impulse at exactly the right part of the pendulum's arc.

A variation of the Hipp principle invented by Herbert Scott has a wheel with double-notched teeth, a gathering pawl normally gathers the whole notch, but on pendulum decay remains in the second, smaller notch and triggers the electrical impulse. If the wheel has 30 teeth and used with a seconds pendulum the wheel can be used to drive the hands of the clock, or alternatively, the electrical impulse can be used to drive a secondary slave dial, or even many slave dials.

The *Model Engineer* Jubilee clock

A series was produced in *Model Engineer* using the synchronome system and called the Jubilee Clock, an update by John Wilding of the original





by E. T.Westbury to mark the occasion of the 60th Jubilee of the magazine in 1958. These ran from October 1992 until June 1993. Described are the various types of Synchronome clock.

With the *M.E.* Jubilee Clock, which uses the Herbert Scott principle, the effect of the magnetic impulse is applied to a sloping surface on a bar attached well up the pendulum, keeping the whole thing compact, and is triggered by the decaying swing of the pendulum. In this type there is a mechanical connection to the hands of the clock and the impulse drives the pendulum about once every two minutes. Both types of clock use the powerful electric magnetic action to drive the pendulum.

The building instructions for the *M.E.* Jubilee Clock, which are to hand, have provided invaluable help in helping to understand the workings of Uncle Doug's clock.

There are now two tasks which I have in mind to do, remake the top end suspension mechanism now that it has been proved, and remake the dial bezel in brass to replace the current aluminium, shown in **photo 10**. The suspension parts are no problem as these are normal turning and milling processes, the bezel is, however, just too large for my lathe and the previously mentioned mail-order company SELVA has nothing of the correct size, so it may be some time before that is done. The case needs no attention at all and reminds me of my boyhood every time I look at it.

The clock keeps time to about two seconds a week and is fascinating to watch, more so when the whole mechanism can be seen as shown in **photo 11.**

TWO HUDSON HUDSWELLS

Derek Lattey
describes models of some unusual narrow gauge prototype locomotives.

These two engines, Class G and Class P, have interesting histories, especially the Class G. This was the famous military engine which did so much good work behind the lines in the 1914/18 war. The Class P was the subject of a painting by David Shephard and the two spent their working lives at the Nigel Gold Mines North East of Johannesburg. A total of 109 of the G were built between 1914 and 1922 of which the military had 77, and two are known to have survived today. *Bronllwyd* at Bressingham is still working but so altered as to be almost unrecognisable. Only the motion, smokebox and chimney are original. The cab has gone and the boiler comes from another engine. An ugly steel plate as also been added to the front buffer beam. The other was on static display in Siam in 1983, beautifully preserved but rebuilt as an 0-6-2 to increase coal capacity. However, the rest of it looks very much as original.

The military Class Gs were sold off at the end of the war and went all over the world. Some are reputed to have gone to Australia and it would be very interesting if anyone there knows what happened to them. Both the Class Ps which went to South Africa in 1924 and 1926 have been preserved. They are on static display, one in the town of Nigel and the other in Gold Reef City, the big Gold Mining museum outside Johannesburg. Another was known still to be working in India in 1992, though much modified with an increased tank capacity.

These engines were both designed by Robert Hudson Ltd., of Gilderstone near Leeds. This well-known firm of light railway engineers mainly concentrated on rolling stock and track; in 1911 they engaged Hudswell Clarke to build their engine designs. Eventually there were 16 different designs which Hudswell Clarke called the Class engines. They are a lovely collection of small machines, mainly well tanks either 4 or 6 coupled, inside or outside frames.

It seems surprising that, apart from the mighty Dolphur, model engineers have neglected this builder. The class engines are very similar to Ornestine and Koppel engines, which have a large following, and a lot of the original works drawings still exist. They are simple and robust, not difficult to build and a joy on the track. Very powerful and, being so heavy, at around $1^1/2$cwt with no carrying wheels, almost unslippable.

Design

The Class G was first met in *Industrial Railways of the South East* (published by Middleton) and I thought how attractive it was. Then came the piece of luck that is essential when building from scratch. I saw copy of R. N. Redman's book *Hudswell Clarke & Co. A pictorial Album of Narrow Gauge Locomotives* on a bookseller's stand at an M. E. Exhibition. This delightful book gave, not only nine photos of the G, from all angles, but also the clue to finding the original works drawings. The story is that when the company closed in 1972 some of the drawings first went to Hunslets and, most of them, ended up in the Leeds Industrial Museum. But they were very unsorted by the time they got there, so locating any particular drawing was very difficult. However, the museum could not have been more helpful and even managed to find the GA drawing and a number of others relating to the valve gear.

Hudson Hudswell G Class.

Simple sturdy frames.

My aim is for a reasonable 'look-alike' which, above all, works well and is a pleasure to drive. Thus bits of existing designs are used together with the castings which correspond, provided they are well proved on the track. Castings can be adapted especially if they have large machining allowances.

As much as could be expected was available for the G, but the P was very different. When I wrote to the museum I got a very stiff reply. This came from a division of the Leeds Leisure Services who had taken over. They stated that they were engaged, in 1997, in a project with the West Yorkshire Archive Service to sort the archive and, perhaps, ultimately transfer it to them. They stated that they also had had problems with claims for intellectual rights over some of the drawings and thus were not confident of being able to reproduce or pass them on. I am told that this situation has now changed.

Fortunately Ron Redman came to the rescue and provided a copy of *Locomotives International* issue No. 21 of 1993. This well-produced glossy magazine includes a most interesting article and seven good photos, all about the Sub Nigel Gold Mine Railway, plus a plan of the track and a lot of history. In addition, he gave me a copy of the original specification sheet for the Class P which was sent to prospective customers by Hudswell Clarke. These photos, the line drawing in the customer's specification sheet and the information given there together with the details of the Class G, similar in so many ways, gave enough to work on.

In the accompanying table the dimensions of the engines are set out showing what they were, as far as could be ascertained and what they should have been, scaled down. Finally, how they turned out when built. Most of the P figures have been found by proportioning the line draw drawing or photos from the size of the wheels and length of the wheelbase. These are marked*

Two features emerge, firstly how small these engines were, with very short wheelbases, and secondly the long overhangs. The latter fact was one of the main difficulties to overcome, which if unsolved would lead to instability on the track.

Starting with the boiler an outstanding straightforward 5in. dia. boiler with no frills is the Maid of Kent design by LBSC. This was used for my Adams 135, so it was easy to chose as the basis for the boiler of the G. The P-Boiler grew out of the G with a wider firebox and longer from backhead to front tubeplate.

When it came to the cylinders and valve gear, slide valves on top connected to Walchaerts was all that was needed and one outstanding example of that is the Simplex. Even if you think it should be dubbed "The Waz of Never Wassies" because it is a model of nothing, when properly built, it is a very fine machine in its own right.

A free steaming boiler connected to the right sized cylinders with a straightforward valve gear and, above all, the correct sized wheels for 5in. gauge. Although I have not built this engine I had plenty of experience in maintaining the club's example and had no hesitation in choosing it. So all the Simplex castings were used except for the dome and the firebox door. But a note of warning must be given when ordering:

The cylinder casting must have no ports cast in as the lateral inclination of the cylinders in both engines brings the line of valve ports to a different place as compared with the Simplex. This was forgotten when the second set was ordered and it caused a lot of bother.

Not much in the way of drawings for scratch-built engines is done except for a general arrangement, side and front elevations and various bits of detail which are completely new to me. For example, the narrow gauge coupling rods. The boiler of course needs a drawing for the builder to work on. The cylinders, pistons and valves, as well as the geometry for the valve gear, come straight out of the Simplex book but heavily modified to accommodate the inclination and the different profile. The lifting arrangements are also very altered.

Frames

The sort of problems which will be met in building an engine can be estimated by a look at the frames. Complicated, curved and full of holes usually mean a difficult engine to build. When researching the Class P the Dukedog series in *Model Engineer* were studied. They are quite horrifying, double and resembling a dromedary with spinal curvature. No wonder the only example I have ever seen won a Gold Medal.

The frames for these two engines are extremely simple. Rectangular with the three slots for the horns and a step at the back end for the cab floor. The G differs from the P in that it has two steps down from the high frames which accommodate the well tank. The only cut out is the lozenge shaped hole under the cab.

The massive crash bars under the frames are a fine feature and most useful for a ground level 5in. gauge engine. My two were built for my garden railway where the track is well in keeping with the sort of metals which these engines were built to run on. They have saved heavy damage to both models when they fell from bench height to the floor in two separate incidents, before I learnt how to handle them.

	Actual		**Scale $^1/_5$**		**Models as built**	
	G	P	G	P	G	P
Gauge	2ft.	2 or 2ft. 6in.	5in.	5in.	5in.	5in.
Cylinders	$6^1/_2$ x 12in.	$8^1/_2$ x 12in.	$1^5/_{16}$ x $2^3/_8$in.	$1^{11}/_{16}$ x $2^3/_8$in.	$1^1/_2$ x $2^1/_8$in	$1^1/_2$ x $2^1/_8$in.
Wheels	23in.	24in.	$4^5/_8$in.	$4^3/_4$in.	$4^3/_8$in.	$4^3/_8$in.
Frames: Length	13ft. 4in.	15ft. 3in.*	33in.	$36^1/_2$in.	$33^3/_8$in.	$34^1/_{16}$in.
Depth	2ft. $4^1/_2$in.	1ft. 5in.*	$5^3/_4$in.	$3^3/_8$in.	$5^1/_2$in.	4in.
Width (inside)	1ft. $8^3/_8$in.	not known	4in.	-	$4^1/_8$in.	$7^{11}/_{16}$in.
Boiler: Diameter	2ft. $1^1/_2$in.	2ft. 4in.	5in.	$5^5/_8$in.	5in.	5in.
Length (front t.p. to backhead)	7ft. 8in.	9ft. 8in.*	$18^3/_8$in.	23in.	19in.	20in.
Height from Track: Boiler Top	4ft. 6in.	3ft. 9in.*	11in.	9in.	$10^3/_4$in.	10in.
Chimney Top	8ft. 6in.	8ft. 7in.	20in.	20in.	$21^3/_4$in.	$21^3/_8$in.
Cab Top	7ft. $11^3/_4$in.	8ft. 1in.	19in.	19in.	$20^1/_8$in.	21in.
Wheelbase	4ft. 2in.	4ft. 8in.	10in.	11in.	$9^5/_8$in.	$10^5/_{16}$in.
Approximate overhangs including cab (P)				Back	$13^7/_8$in.	$13^7/_8$in.
and substantial NG couplings				Front	$9^7/_8$in.	$9^3/_8$in.

Wheels and suspension

These require some planning due to the long overhangs. The castings used were the 17 spoke Simplex castings with seven spokes cut out for the G to give the nine spoked wheel as per the original. The tenth spoke remains completely hidden by the narrow gauge coupling rods and gives extra strength. The horn castings are those often used for the Simplex being 3/4in. wide. All the springing is above the axle box which is a great advantage for engines with low slung frames which are going to be run on rough track at ground level. The leading intermediate wheels have no flanges, as in full-size, so both can easily negotiate curves of 16ft. which exist on the reversing triangle in my garden.

The suspension was developed by trial and error. The long leaf springs built with spring steel only were totally inadequate. The final solution was three leaves made out of 3/8in. wide spring steel with 6, 4, and 3 lengths of spring starting from the bottom. On top of these are three pieces of rigid 1/16in. mild steel . Thus only three of the leaves bend at their extremities. The spring pins are split in the middle running into a top hat type fitting with two stiff springs around each other for the leading wheels.

On the leading intermediate wheels there is only one spring thus giving differential springing which is essential to prevent gross rocking with such long overhangs. The springs are stainless steel safety valve springs with 3/16in. bore and a hefty coil spring round them with a 5/16in. bore. The 2BA bolt through the leaf spring pivot is naturally screwed up hard to prevent the spring rocking fore and aft.

The driving wheel springs are the same as the leading axle with the top hat fitting the other way up and a hefty screw thread on the upper half which can be screwed down to equate the tension on the leading axle, which also has the leaf springs on it. This works and the engines are steady on the track despite the short wheelbases and the long overhangs. The photo of the completed frames and motion gives a good idea of the suspension.

Motion

This is built on the basis that the important part is the assembly between the valve crosshead and the drive pivot at the bottom end of the expansion link. Provided the geometry of this is right it does not matter how far the cylinder or the driving axle is away, so long as the return crank is the right length and properly set. Of course the length of the eccentric rod must be found by the usual method. So the Simplex book will give the dimensions needed and it is only a matter of fitting it in and beefing it all up to 1/5 scale. The piston rods are 5/16 inch.

A number of drawings were created of a poor quality, but they were perfectly adequate. They include the motion brackets expansion links, crossheads cylinder front elevations and portfaces. The lifting arrangements are a little daunting in prospect. However, it all fits in if the motion brackets are fabricated from 1/8in. steel plate and the lifting link pins on the radius rod are placed 11/16in. from the die block pin centres. The crossheads must be no longer behind the gudgeon pin centres than 1/2 inch. The weighshafts are a bore as they demand to be located either all mixed up with the leaf spring pivot bearings for the P or the aft end of the same springs on the G. From the photos it can be seen that the lifting arms are reversed and reach over the motion brackets on the P. They had to be longer than the scale originals.

The inclination of the cylinders fore and aft and laterally do not pose any great problems and are very much a matter of choice, except for the lateral inclination for the G. This is required as the space between the frames is completely filled by the tank. Thus steam and exhaust must come out of the cylinder and valve chest between those and the frames. The exhaust coming out of the middle of the cylinders is the determining factor. A fabricated bend was made and set the inclination which was 13/16in. from the top inside corner of the port face to the frame.

When setting out the lateral inclination of the cylinders there are three dimensions to be maintained. The 1 5/8in. lateral displacement of the centre of the cylinder bore from the frame, the 7/16in. further displacement to the valve rod and the vertical distance of 1/2in. of the valve rod from the top of the port face. It sounds very complicated, but it is not difficult when laid out on a piece of paper. The cylinders are naturally rotated round the piston rods.

The P's cylinders were easily inclined by machining the bolting faces of the castings as there was so much fat. The G needed machined pieces of angle let into the ends of the cylinder blocks holding them at the correct angle and bolted outside the ends of the block to the frames. Thus the positioning of the cylinders on the frames is not a difficult job as the frames can be drilled through the holes on the mating faces of the angle with the cylinders clamped in place.

As in all scratch building a facility for drilling holes from inside to outside of 5in. gauge frames is essential as the exact location of components is seldom decided in advance. The P cylinders attached with 2BA bolts very much need this.

The narrow gauge coupling and con rods are a joy as, provided they are deliberately made the wrong length you don't face the awful moment when the wheels won't go round when first fitted, or your pistons hit the cylinder ends.

They consist of a 3/4in. square axle box with a 1/16in. deep flange 3/32in. wide all round and 9/16in. bored holes to carry a bronze bearing. They are mounted in a rectangular hole and are set with fitted spacers. So, if they are all made too long towards the central wheel axle it is an easy job then to file out the extra metal until the wheels go round. Then make the final spacers on the outside end and complete the profiling so that the shoulders are in the right place. The con rods were treated in the same way, made too long and then shortened. The only difficulty was making myself leave the rectangular holes long enough in the first machining so that a large spacer was needed. They do show a lot on the originals.

The con rods are treated in exactly the same way being first made to hit the cylinder covers then shortened. The axle boxes are made in sticks on the milling machine chopped off with a slitting saw, drilled and bored and then the best of the sticks selected.

P class in 5in. gauge.

Saddle

These are ad-hoc steel fabrications and seemed to be interminable when building. A casting would be a great help but it would have to be very wasted on the P as it would be otherwise very heavy.

Main steam and exhaust pipes

The steam and exhaust pipe arrangement for the P are based on the Simplex as per the book. A straightforward T for the exhaust and the steam pipes leading to the two 1/4in. stainless steel radiant super heaters (Paul Gammon) attached to them with the usual large union fittings. The G was completely different and by no means easy. Fortunately the very long chimney forgives lack of alignment of blast pipe and blower ring with the centre of the petticoat.

The whole arrangement is in three pieces starting with the fabricated screwed-in fitting which takes the exhaust through its first bend to the vertical. A flange then attaches the fitting to the exhaust pipe which then turns through

90deg. over the frames and is finally silver-soldered into a brass fitting into which the blast pipe is screwed.

The outside steam pipes on the G are joined to the steam chest by a screwed fitting to a flange and then another length of pipe joined to the superheater with another flange inside the smokebox. This flange can be removed from outside the smoke box and the rectangular covers through which the pipe passes are made airtight by a large Purimachos seal.

One small joy of this arrangement is that the $^1/_4$in. stainless steel pipe takes a 2BA internal thread very nicely. Thus the removal of the external steam pipe and a 2BA bolt is all that is needed for boiler testing.

Final livery is from Merstham quarries.

Boilers

Both the boilers were built by Western Steam. The G by the Late Ron Walker and the second by Ms Helen Verall, who has the final drawings and details of materials. They are both wonderful pieces of boiler-making and very fine steamers. They are really a Maid of Kent boiler with rectangular traction engine type fire boxes. The G has an asymmetric foundation ring. The outer wrapper being 5in. wide with a foundation ring $^1/_2$in. wide down the sides and $^3/_8$in. across front and back, giving a 5 x $3^3/_4$in. outside measurement firebox. This sits on top of the frames with the firebox extension between the frames. Two $^1/_2$in. superheater tubes and 3 x $^7/_{16}$in. dia. tubes comprise the top row with 6, 5 and 4 x $^7/_{16}$in. fire tubes beneath them. The dome ring casting is the Maid of Kent's machined to the Maid's dimensions. The P boiler sits on substantial pieces of angle attached to the frames. The firebox here is symmetrical with a $^3/_8$in. foundation ring all round. Again it is mounted so that the firebox extension sits down between the edges of the supporting angle. The P is only 1in. longer than the G between tubeplates so that the smokebox for the P is rather long, disguised by extending the boiler tube.

The alterations between G and P were kept to a minimum as the G had turned out to be such a fine steamer. So $^1/_4$in. wider firebox has supported a 1in. longer barrel as they are as good as each other. The backheads are conventional with a $1^1/_2$in. firehole with correct? laterally sliding fire doors. The P differs from the G only in that the P has the extra bushes to take the boiler feed, the G being fed through the sides of the barrel.

The regulators are the same, a vertical slide letterbox which is easy to make, the idea coming from the Butch drawings and it works well. I deliberately make them with a long dead rotation to begin with so that a better seal is obtained.

Tanks and cab

A well tank is not easy. To start with it is a box at the front narrowing to a rectangle which is shallower to get above the axles. Both engines have rectangular additional tanks in the bunkers. The G tanks are filled through the coal bunkers, which are open to the sky, with the filler caps disguised with coal. There is no way to know how much water is left in the G's tanks as they are stepped and displaced from each other. So a protected sight glass has been fitted down the back of the cab. The P has a gauge on the back of a bunker. The hand pump for the P is inside the right-hand bunker tank which is a straightforward installation. The G is under the cab as it must be as low as possible to be much use. They are both redundant axle-driven pumps removed from earlier engines. Double acting, and they make fine hand pumps, but the pipework is elaborate. Piping up the G is a nasty job as the water must be taken from the bottom of the well tank. Three pipes to be fitted for the pump and two injectors. This was the job which caused the crash off the bench, fortunately my hands and feet were not involved, but only just. The cabs are up to the builder and not difficult. These are made to be removed as easily as possible.

Liveries and historical modifications

The G must have been black when in W.D. service with a simple W.D. number on the cab. The green with white lining and legend is correct for the two which ended their lives in the Merstham quarries. I have spoken to a man who used to drive them and still lives in Redhill.

The P went through many changes and perhaps the best indication of the colour is David Shepherd's painting 'On the Sub Nigel in the Transval', 1962. Good copies of this painting can be obtained from the West Somerset Railway. From this my green is a little too dark and of course at that stage Tiger Stripes had appeared on the buffer beams. Later a car touch-in black and yellow was added round the legend.

Modifications of narrow gauge engines are an owners disease. What a fine example of that is *Bronllwyd* at Bressingham. Most of the modifications carried out to both these engines were to provide more coal or water capacity. The Gs at Merstham remained little altered at the end of their lives. The only modification identified being the removal of the brass displacement lubricator from behind the chimney and the fitting of a mechanical lubricator on the right-hand side.

The Ps were very modified. A bucket shaped bunker was added at the bottom of the cab at the back. The sand box had been removed and a steam generator added to feed the headlight. A large steel plate had been fitted under the cylinders, attached to the bufferbeam and extending to cover the drain cocks. It was this modification which caused me to increase the inclination of the cylinders to get the drain cocks a little higher. I also moved the crash bars a little to help with this problem. Two handrails were added on the bufferbeam and, I think, the bufferbeams were extended sideways. There was also a large toolbox door on the bottom front end of the left-hand bunker which was added.

The future

Class P is obviously valued in South Africa. I have seen the engine in the Museum but I do not know what state the Nigel engine is in. The Gold Reef City engine was well painted a darker green but a lot was missing, most of the brass fittings. But the G deserves special treatment. We must consider ourselves lucky to have a working example still existing and be grateful to the owners at Bressingham for that. However, these are historic, indeed heroic engines and I do think the class should be better preserved than the present condition of this engine. They were used to carry trench making materials, food, guns, ammunition and even soldiers up to close behind the trenches. What they brought back must have been dreadful. I wonder how many soldiers owed their lives to a speedy evacuation behind one of these when badly hurt.

Would it be out of place to suggest that *Bronllwyd* might be restored to its original condition? Perhaps a subscription might be raised for this purpose. Nothing would please me more if model engineers wanted to build one of these, especially the G. That took two years and five months to build including plans and the P was finished before the boiler certificate for the G ran out.

They are both very basic engines with only the essentials present. Indeed a friend of mine who knew said the G looked like an engine built by an accountant; and that is precisely what it is!

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EDWARDIAN ELEGANCE: THE GREAT ORME TRAMWAY

Ron Isted

continues the saga of this fascinating, British engineering masterpiece.

●*Part II continued from page 156 (M.E. 4279, 4 August 2006)*

In order to find out just what Henry Sutcliffe got up to, we need to move forward a quarter of a century to 23 August 1932. Just after midday on that fateful Tuesday, Driver Edward Harris was descending the lower section with car No. 4, laden with holiday makers, in addition to which, and contrary to company regulations, the 12 year old daughter of a tramway employee, Margaret Worthington, was travelling with him on the front driving platform. She was returning home after having delivered a packed lunch to her father, on duty up at Summit Station. At the steepest part of the gradient near Black Gate, the steel drawbar attached to the haulage cable suddenly fractured without warning. Instead of being brought to an immediate halt by means of its emergency brake, the car broke loose from the cable and, despite the application of both wheel and slipper brakes, accelerated rapidly until it left the rails on a reverse curve and hit a stonewall. With great presence of mind, Driver Harris grabbed the young girl in his arms and jumped from the vehicle, but tragically, it lurched over, crushing both of them against the wall. He was killed instantly and young Margaret died later in hospital, while ten passengers were seriously injured, largely as a result of being struck by a cascade of coping stones as the car scraped along the wall.

At the Ministry of Transport Inquiry, it transpired that the drawbar had fractured because no proper metal specification had been sent to the manufacturers. Neither had they been informed of its intended use and had fabricated it from a heat-treated alloy steel called Vibrac, quite unsuitable for the purpose. One might wonder why, in view of the lack of information supplied by the tramway company, no one from the firm had thought to check with the company before actually making the item, but this question was apparently not asked at the Inquiry. One disturbing revelation that did come to light was that the drawbar on car No. 5 had failed only two days earlier, but the vehicle had fortunately been brought safely to a halt. In spite of the potentially serious consequences, this previous incident had been completely ignored and none of the drawbars on the other three cars had been inspected for possible flaws. A brand new one of the same type had been fitted to No. 4 as recently as 15 August. After just one week in service, its initial $^3/_4$in. thickness was found to have been reduced by no less than $^1/_8$in, due to what Manager Sutcliffe referred to as 'surface rubbing'. This startling fact would not have been discovered if Lt. Col. E. P. Anderson, who chaired the Inquiry on behalf of the Ministry of Transport, had not insisted on the remains of the fractured drawbar being produced by the police. Finally, most seriously of all, the Inquiry discovered that *"cars Nos. 4 & 5 had been operating for the last 26 years without their emergency braking system"*, as Henry Sutcliffe had had the cam-teeth removed soon after his appointment. He had also disconnected the governor on the steam winding engine, an equally foolhardy and potentially dangerous course of action.

As a direct result of these horrific revelations at the Inquiry, the Insurance Company not unnaturally refused to foot the £14,000 bill for claims from injured passengers and after one of them had obtained a writ, a Sheriffs Officer was called in to take possession of the entire system and post notices of the sale of the line, in order to pay off the claimants. The tramway company immediately went into liquidation, though the creditors agreed to continue with trials of a new emergency brake, but only in order that the tramway could be sold as a going concern. It was finally sold in December 1934 for just £5,600, having cost nearly £20,000 to build 32 years earlier. The new company was known as the Great Orme Railway Ltd., although the lines remained legally a tramway and tramroad. Throughout this traumatic period of upheaval and change, guess who remained as manager and actually continued in the same job until he retired in 1945? As far as I can tell, Henry Sutcliffe appears to have received no official reprimand whatsoever, 'The Management' being blamed entirely for the disastrous breaches of regulations. One very odd co-incidence is that one of the six directors of the new company was one Arthur Sutcliffe, described in the relevant documents simply as 'a gentleman', but whether he was related in any way to the manager of the tramway I am unable to say. Margaret's father also continued to work for the tramway and one can only try to imagine his feelings in future dealings with Henry Sutcliffe.

5

The 'Give Way' sign near Black Gate with the steam driven locomotive symbol below on 15 Sept. 2006 (photo: Ron Isted).

6

The end platform and entrance to the central saloon of No. 4 St. Tudno on 15 Sept. 2005 (photo: Ron Isted).

At this point, I would like to emphasise that this is the only fatal accident in the line's 103-year history. When you consider that not far off 15 million people have used the tramway since it opened, it becomes obvious that you are in very much greater danger in your own home (or workshop) than riding on the Great Orme Tramway! In any case, with today's rigorous annual checks of every detail of rolling stock and infrastructure by the Railway Inspectorate, any breach of safety regulations would very quickly come to light. Digressing slightly, but still on the subject of safety regulations, I was somewhat amused on my recent visit by the 'Give Way' signs for road traffic that stand not far from the site of the 1932 accident (**photo 5**). Ironic really, as the one form of mechanical motive power forbidden to the G.O.T by its original 1898 Act of Parliament was steam!

The new emergency brake comprised four skids with steel teeth, mounted beneath each vehicle, which automatically bore down on the concrete road surface either side of the running rails if the speed exceeded $6^1/2$ miles per hour. The main difference from the previous system was that it was controlled by a governor and depended on speed instead of changes in tension on the drawbar. On 23rd March 1934, car No. 5 was loaded up with scrap iron and gave a convincing demonstration of the new brake, bringing the car smoothly to a halt in less than half its own length. After a further test by the Ministry of Transport (which had replaced the Board of Trade Inspectorate), both sections of the line were finally permitted to re-open on 17th May 1934, having been closed down for almost 21 months. Because the new brake operated on the road surface, the original slipper brake, together with the associated handwheels, were removed from cars 4 and 5, as the efficacy of the emergency brake would have been reduced by any application of the slipper. They are, however, retained on Nos. 6 and 7 on the upper section.

A miniature version of the Great Orme Tramway could be just the job for the model engineer who would like a rail system in his garden, but is put off by the thought of the earthworks required to iron out the gradients! Most model tramways, whatever the gauge of the prototype, are built to $3^1/2$in. gauge, which in this case produces a nice round figure of 1in. to the foot. However, one word of warning: if you wish to reproduce the system exactly to scale as regards length and grades, you will need a garden over 400ft. long combined with a change in level of about 45ft., of which roughly two thirds should be in the first 200 feet! But of course, a highly successful and convincing looking version could be installed in a far shorter length. The design and installation of the track and conduit for the lower section would be a very interesting exercise, but I would suggest it would require a substantially over-scale thickness for the concrete infrastructure, in order to avoid a never-ending battle with the elements. As we have seen, the winding house can be powered by either steam or electricity, depending on the period modelled. Unfortunately, few technical details of the steam plant seem to have survived, a fact that may help to silence a few of those armchair critics who cannot wait to air their superior

***No. 5 St. Silio** ascending the 1 in 3.8 gradient near Black Gate on 15 Sept. 2005 with one passenger (photo: Ron Isted).*

knowledge - although on second thoughts I doubt it. All the publications I have consulted also state that no photographs of the steam haulage engines are in existence, but thanks to the kindness of a current member of the tramway staff, Danny Jones, I can say that this is not so. Mr. Jones' brother-in-law took two excellent photographs of the larger Musker engine (then operating the upper section) in the early 1950s, and he has very kindly supplied me with photocopies which I would willingly lend to anyone seriously contemplating building a model of the tramway in the days of steam operation.

The vehicles themselves are basically simple wooden boxes with steel frames and steel reinforcing panels, but I am certainly not competent to advise would-be constructors on how to build a miniature version. I have, however, listed an excellent book on miniature tramcar and tramway construction in the references at the end of the article, and a few more constructional details of the full-size vehicles may be of assistance to potential builders. The entrances from the driver's platform to the central saloon (**photo 6**) consist of a fixed half glazed panel at either side plus a sliding entrance door, also half glazed. In later years, safety rods were fitted on the driver's side of each window, three rods on Nos. 6 and 7, the upper section vehicles, and two on Nos. 4 and 5. Other later additions, to Nos. 4 and 5 only, included water tanks at each end, operated by a foot control, to water the track on the sharp curves of the lower section, and dog-gates, locally referred to as cow-catchers, extending over the entire length beneath the body between the boarding steps. I'm sorry to say I do not know when these modifications were carried out, but they were certainly there when I first visited the line in 1955, and probably pre-date World War II. More recent additions to all four cars include the platform side-doors mentioned above, and the radio control antenna fitted to the bottom front corners of all bogie frames, both dating from 1990/1.

The colour scheme of the vehicles when the line first opened is not known for certain, but early hand-coloured postcards show a deep yellow for the body, with white roof and lettering, with the number only on the side, directly below the first window pillar from each end. The words 'GREAT ORME TRAMWAYS' (in the plural) were on the same level as the numbers, between the three central window pillars, as shown in fig. I. Lettering was serif, with the initial letter of each word somewhat larger than the rest, but I am not sure of the exact sizes: scaled off various early and rather indistinct photographs, they appear to be about 7in. and 6in. respectively. The two upper section cars, Nos. 6 and 7, carried the same lettering, even though they operated on what was legally a tramroad. At an early point in the line's history, royal blue became the main body colour, with what appears from contemporary photographs to be black panel edging separated from the blue by a thin (white?) line, and at a later date, the numbers appeared additionally on front and rear panels. When the new company took over operations for the 1935 season, the lettering was changed to 'GREAT ORME RAILWAY', and this remained standard until the 1970s. The main body colour became darker and darker with successive re-varnishing and by the time I first saw it in 1955, it could best be described as very dark brownish blue. In 1962/3, all four vehicles were stripped of their many coats of paint and varnish, to be repainted in the original royal blue with black lining. Roofs, numerals and lettering (still 'GREAT ORME RAILWAY') were white, while trolley poles and everything below the footplate were black. The interior of the saloon was dark brown with a white ceiling. A few years later, the scheme was changed to a more upbeat two-way combination of blue and cream, (officially referred to as ivory): body panels were blue, lined round the edge in cream and divided into two by an additional cream line along the horizontal centre moulding, while upper works were all cream. The numbers were now centred just beneath the front and rear window spaces in the upper side panel, and those on front and rear, although the same size, were positioned slightly higher. The lettering was changed to 'GREAT ORME TRAMWAY' (singular!) in serif capitals of uniform size with a decorative scroll either side, and centred in the lower blue body panel, i.e. well below the level of the numbers. Roof, ironwork details and everything beneath the body were black, as was the vertical corner edging of the saloon body.

With the complete refurbishment of the system from 1990 onwards, came the striking current colour scheme, officially described as orient blue and gold, although it incorporates an almost equal amount of black and white (**photo 7**). The main body panels and side doors are orient blue, with no horizontal dividing line, but lined round the edge by a broad gold band with a narrow one inside it. Corners are in-curved, with a decorative figure outside each one (**photo 8**). The vehicle number appears only on the front and rear panels, in gold shaded to the left and below in a lighter blue and the side panels are lettered as in the previous scheme, but in larger serif capitals with a gold filigree each side (**photo 9**). In passing, No. 4 has no lettering on the left side at the time of writing, as some repair work was required recently on the body panel, which entailed rubbing down the paintwork. As all the sign-writing is done by hand, an expensive and time-consuming business, the lettering will not be replaced until the end of the current (2005) season. The initial letters of each word are larger than the others, a pleasing reminder of the original 1903 scheme, although today's lettering is more than twice the size of that of a century ago. Everything below the footplate is black, as are the platform ironwork, the roof and the now disused trolley poles, which have been permanently swung round across the centre of the roof. Otherwise the upper works are black and white, with the exception of a narrow blue panel just below the roof, on which is inscribed the name of the tramcar in gold letters, all four having been named after saints: No. 4 *St. Tudno*, (**photo 10**), No.5 *St. Silio*, No.6 *St. Seiriol* and No.7 *St. Trillo*.

Now it will be fairly obvious that the above names refer to Welsh saints, but some of our eagle-eyed marine specialists may have spotted that they are also the names of ships belonging to the former Liverpool & North Wales Steamship Co., and I cannot resist the temptation to go off at a tangent by including a photo of the nautical *St. Tudno*, (**photo 11**). She (or he) was an elegant 318ft. turbine steamer, built in 1926 by Fairfields and capable of 19 knots, which spent most of her life on the Liverpool - Menai Bridge/Llandudno run, although I was fortunate to travel on her on a day excursion from Llandudno to Douglas, Isle of Man, when I photographed her in 1955. She survived until 1963. My only (flimsy) excuse is that I hope to include an Edwardian turbine steamer in this series of articles, but for now I

The front of No. 4* St. Tudno *in Victoria Station on 15 Sept. 2005 (photo: Ron Isted).

will merely apologise for this watery and completely unjustified diversion and return to the rail-bound Saints of the Great Orme Tramway.

Since 1949, the tramway has been operated by local government, initially Llandudno Urban District Council, then Aberconwy Borough Council, through its trading arm, Grwp Aberconwy and currently Conwy County Borough Council. Unlike so many government run commercial concerns, the council very obviously has great faith in its unique line and has proved it by putting its money where its mouth is. An ambitious, (and expensive - around four million pounds), investment programme has seen complete track renewal, rebuilding of all three stations, total refurbishment of the four centenarian passenger vehicles, replacement of the communications system, and more obvious to the general public, the use of the most eye-catching colour scheme in the line's history, together with smart matching uniforms for the staff introduced for the 90th birthday celebrations in 1992. Incidentally, at the centenary celebrations ten years later, the Llandudno Town Band was once again present to play the National Anthem, just as it did on the opening day in 1902.

The current owners have also made a determined effort to advertise the line to a greater extent than at any time since it first opened, and have expressed their intention of making the Great Orme as famous as the San Francisco system, so perhaps the Welsh at least are finally overcoming the traditional British distrust of publicity. The original Act of Parliament of 1898 stipulated a fare of 6d, ($2^1/2$p) single and 9d, (just under 4p) return, which by 2005 had become £4.50 return, single fares being discontinued. Now, before you throw up your hands in horror at this increase of 12,000% over the last 104 years, may I just remind you that when Arthur Drummond brought out his famous round-bed lathe around the time the Great Orme Tramway first opened, the price, complete with a generous number of accessories, was - wait for it - £5.

Acknowledgements and References

1: Neil Jones, Great Orme Tramway Operations Officer, Danny Jones and other members of the tramway staff have been very helpful, supplying much information and patiently dealing with many questions.

2|: Glyn Wilton and John Shawcross of The National Tramway Museum, Crich, Derbyshire for correcting wrong dimensions and supplying an excellent bibliography about the G.O.T.

3: *The Tramway and Railway World*: October 9 1902 (courtesy of National Tramway Museum). Detail drawings and description of track, photograph of lower section track before concreting over, two photos of vehicles and dimensions (some incorrect.) No drawings of the vehicles.

4: Terry Russell Drawing TC 456: undated (courtesy of National Tramway Museum). 4mm to foot side and end elevations and plan of car No. 5. Unfortunately, this is based on the inaccurate dimensions quoted in ref 3, and has introduced further errors of its own: for example the seating plan is completely wrong.

5: Great Orme Railway: R. C. Anderson, pub. *Light Railway Transport League*, undated (c. 1966). Largely a reprint from the author's article in *Modern Tramway* magazine. An excellent 20-page booklet, giving much historical and

Lettering on the side of No. 4* St. Tudno *in Victoria Station on 15 Sept. 2005 (photo: Ron Isted).

The hand-painted name of* St. Tudno *in Victoria Station 15 Sept. 2005 (photo: Ron Isted).

technical information, but again perpetuating the incorrect dimensions given in ref 3. Good selection of photos, though unfortunately the quality of paper and photographic reproduction 40 years ago leave something to be desired.

6: *Great Orme Tramway*: Rosemary Sutton, pub. Grwp Aberconwy, 1992 (courtesy National Tramway Museum). Excellent 90th birthday celebration booklet, also 20 pages. Good general historical and technical information, and several very good photos in colour, well reproduced, but also contains some very inaccurate ink and wash drawings.

7: *North Wales Tramways*: Keith Turner, pub. David & Charles 1979. Good general history, although one or two dates are suspect. More detailed than ref. 5.

8: *Scale Model Electric Tramways and How To Model Them*: E. Jackson-Stevens, pub. David & Charles, 1972. Excellent and very readable instructional book, good drawings and photographs. Deals with track and control systems as well as vehicle construction.

9: The tramway website: **http://www.greatorme.org.uk/tramway.html**

This website, organized by Noel Walley, includes an excellent brief history and historical and modern photographs of the line.

10: Website: **http://www.dewi ca/trains/gt-orme**

Run by Dewi Williams, this contains superb archive photos taken in August 1952 of vehicles, track layouts, buildings, including detail shots of bogies, track pulleys etc. - very useful for model engineering purposes.

11

The Liverpool & North Wales Steamship Co. turbine steamer St. Tudno *departing Llandudno after a day excursion to Douglas, I.O.M., 1st Sept. 1955 (photo: Ron Isted).*

Great Orme Tramway Vehicles: Dimensions

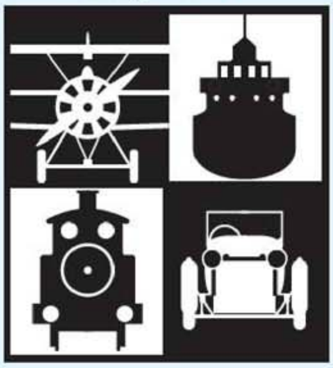
Notes: a) 1 in. scale figures calculated to nearest $^1/_{64}$in. b) Dimensions prefixed by = have been scaled from various photographs and may not be exactly correct. c) Bogie wheelbase and distance between centres are at variance with official figures published for the last century or more, but have been measured from the actual vehicle!

Description	Full size	1in. scale ($3^1/_2$in. gauge)
Track gauge	3ft. 6in.	$3^1/_2$in.
Overall length over couplers	38ft. 10in.	$38^{53}/_{64}$in.
Length of vehicle body, exterior measurement	37ft.	37in.
Maximum width over footsteps	7ft. 9in.	$7^3/_4$in.
Width of body, exterior measurement	7ft. 6in.	$7^1/_2$in.
Height from rail level to top of roof	=9ft. 7in.	$9^{37}/_{64}$in.
Height from rail level to top of trolley pole mounting	=10ft. 6in.	$10^1/_2$in.
Length of trolley pole	=10ft. 9in.	$10^3/_4$in.
Height of body, exterior measurement	=7ft. 0in.	7in.
Length of saloon, exterior measurement	30ft.	30in.
Width of saloon, interior measurement	7ft. 0in.	7in.
Height of saloon, interior measurement	6ft. 6in.	$6^1/_2$in.
Length of end platforms	3ft. 6in.	$3^1/_2$in.
Height of platfonn from rail level	=2ft. $8^1/_2$in.	$2^{45}/_{64}$in.
Distance between bogie centres	23ft. 4in.	$23^{21}/_{64}$in.
Bogie wheelbase	3ft. 9in.	$3^3/_4$in.
Diameter of bogie wheels	1ft. 9in.	$1^3/_4$in.

IN THE NEXT ISSUE

- **Guildford Rally**
- **Colchester Lathes**
- **Stoichiometric Ratios**
- **Welshpool & Llanfair Railway**
- **OHV Steam Engines**

Plus 2006 Model Engineer Exhibition Entry Form



As well as all your regular favourites

ON SALE 15 September 2006

Contents may be subject to change

KEITH'S COLUMN

LILLIAN
A NARROW GAUGE LOCOMOTIVE
for $7^{1}/_{4}$in. gauge

Keith Wilson continues work on this project but starts with some notes on insults and overhang.

●*Part XXIV continued from page 163 (M.E. 4279, 4 August 2006)*

As might be expected - it happens to us all - over the ages I have collected a number of compliments and insults. It is not always easy to decide which is which. But one of the best was to hear a comment from the chargehand of the factory assembly departments.

*"The thing I like about Keith is that if he gets it wrong, he always holds his a**e out for kicking"*. A complement, for sure. Another one was when I was giving a talk to a model engineering club, when I was introduced as a *"living legend"*.

Whether my eldest son was justified in adding the prefixes *"barely"*, *"almost"* or *"just about"* on various occasions is a case for imagination. But he forgot *"unfortunately"* and *"regrettably"*. Any questions?

Overhang

My reader(s) will have noticed the big overhang towards the rear of the locomotive. It would be possible to put in a trailing pony truck or something similar; but as far as weight distribution is concerned I don't think it necessary, for those cylinders near the front, to mention nothing of the smokebox and boiler, are pretty heavy. Also, any trailing truck would reduce the affective adhesion of the driving wheels.

I mentioned this many years ago, (and was 'hauled over the coals' by some well-meaning folk who were not so mathematically informed) but a repetition will do no harm.

When a locomotive on straight track is pulling, there are just two horizontal factors involved.

One is the pull through the drawbar, the other is the reaction on the rails. These forces are parallel, equal, and opposite. This results in what is mathematically known as a 'couple'. Now the most important thing about a couple is that no matter how we may try, it can *not* be neutralised except by another couple, equal and opposite. This first couple is trying to tip the locomotive backwards. Since the locomotive does not tip over backwards, this 'secondary' couple must come from somewhere.

> ***Wilson's Words of Wisdom:***
>
> *The unexpected always happens.*
> *J. B. S. Haldane*

The only possible source of this couple is the weight on the wheels. This manifests itself through the centre of gravity.

The first couple's magnitude is decided by one of the forces multiplied by the distance between them, this distance being the difference between rail top and drawbar. This couple applies everywhere in the scene, no matter where we are. But, remembering that a couple can only be balanced by its equal and opposite, the result is the shifting backwards of the effective centre of gravity; hence the locomotive will tend to dig in its heels.

In the case of 0-6-0s, this amounts to a ton or so and can be effectively taken from the front driving wheels and put on the rear drivers, and doesn't make much difference. For locomotives with any form of leading truck, be it pony or bogie, this weight will largely come from this leading device and manifests on the driving wheels. For locomotives with a trailing truck (Pacifics, Atlantics, Mountains, etc.), adhesive weight comes off the drivers and onto the trailing device where it is wasted - except for the rare cases where a 'booster' is fitted to the trailing device. I believe that the LMS or the LNER used one of these on a Pacific (4-6-2).

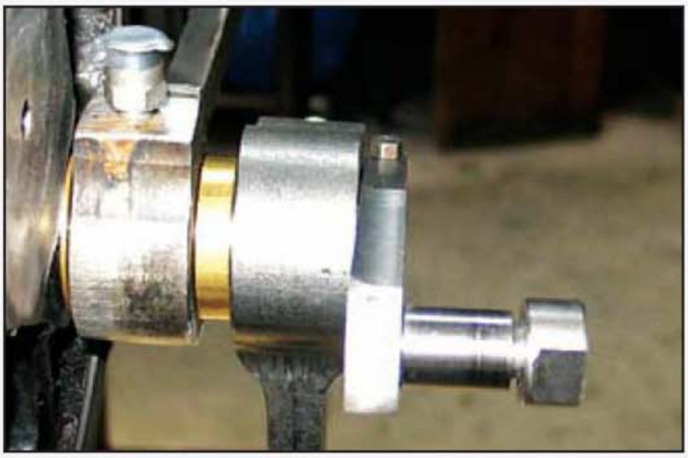
This accounts, to some extent, for the performance of the oil-fired 2-6-0 on the Great Western when it ran the famous Bristolian for a week, a locomotive very much smaller than the usual King or Castle. The other main factors were skill on the part of the driver and the fact that this particular 'Mogul' was oil-fired. Generally speaking, oil-firing puts about another 50% on steaming capacity.

Back to overhangs

One problem is that there could be a lot of sideways overhang when traversing curves. It is not possible to calculate exactly how much, for the sideways clearance of wheels, track etc. is not easy to measure, but an idea of the said sideways overhang can be roughly calculated. Treating given dimensions as exact, with no side play, the offset on the *Lillian* centre driving wheels is 0.0675in. for a 50 foot radius curve. This comes out to about 0.801in. at the rear buffer plate, so there is not a lot to worry about.

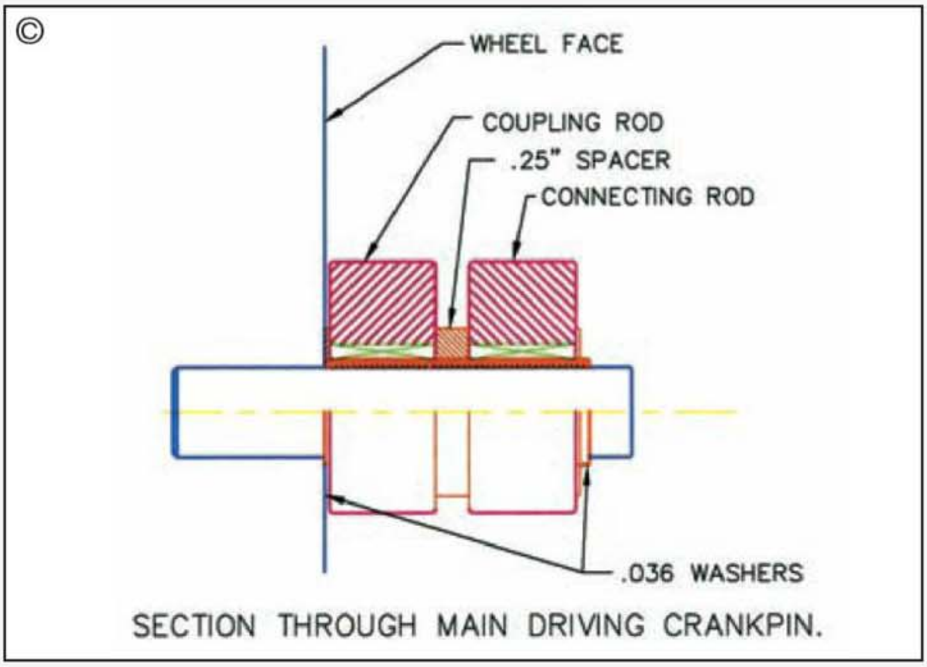
For those interested in calculating matters like this, divide half the driving wheelbase by the radius of the curve, remembering to work in the same units i.e. all inches or all feet. Take the arcsine of this result, and multiply the radius by the cosine of this angle. Then subtract this result from the radius and there is your overhang. Alternatively, take the radius from the result and ignore the negative sign that will shew; this can make it a bit easier for those using pocket calculators. If you use the 'calculator' program on Windows set-ups, you might well find an answer given to 32 decimal places!

If you want the overhang at the rear of the engine, double the distance from the driving wheelbase centre to the rear buffer plate and divide by the radius of the curve. Find the arcsine of this result and multiply its cosine by the radius as above. Subtract the radius from this figure and there is your approximate overhang. Not accurate, but gives an idea. For those who don't know (or possibly do not remember!), the arcsine of 'x' is 'the angle whose sine is x'. Remember



The spacers on the main drive centre crankpin

The fork-joint pivot and C-nut assembly on the centre wheels.



that you are looking for a very small figure (the overhang) from a large figure (the radius) and will need to note quite a few significant figures in your calculations. A point to note is that the formula as given below automatically halves the wheelbase figure, hence 'double the distance from the driving wheel etc.'

To allow for this overhang when considering the coupling betwixt engine and tender, make the hole in the rear buffer plate into a slot about 3in. long, and the drawbar longer than it appears to need, pivoting it to a point a few inches in front of the buffer plate - a piece of flat steel welded between the frames suggests itself. I suggest you aim at a gap 'twixt engine and tender from 1.5in. to 2in., which should cover your needs. Also put the tender 'pull-bar' back from its front buffer plate; it will help.

There is another way - harder - of doing these calculations, using our old friend Pythagoras and having to solve some quadratic equations - I admit that I used to do it that way - but it was only on writing this article that I saw the easy method described. How often do we miss the obvious?

For those good folk who have Excel on/in their computers, enter the curve radius in inches into cell A1, and the wheelbase in inches into B1. Enter the formula below into C1, press 'enter' and in C1 will appear the approximate overhang at the centre of the wheelbase. For overhang at front or rear, instead of the wheelbase in A1, enter double the distance from centre of wheelbase to the front or back of the engine. Once again, press 'enter' and front or rear overhang will appear in C1. *"Everything is easy once you know how"* as LBSC used to say.

Remember the famous (albeit false) statement *"To err is human, but it takes a computer to really mugger things up"* and the usual used word is not *"mugger"*. As a check, the overhang at the centre wheels of *Lillian* is 0.067503797in. on a curve of 600in. (50 feet) radius, so if your computer says something different then either you have entered the formula incorrectly or 'boobed' on radius and/or wheelbase.

The formula is:
Overhang =A1- (Cos(Asin(B1/(2 x A1)))x A1

But it is not over-accurate for front or rear overhangs, just gives an approximation on the low side.

Remembering that the 'scale' wheelbase (8in.) would have an overhang of 0.0533in. at the centre wheel, we have not seriously 'sabotaged' curve flexibility by increasing wheelbase to get a good braking system in.

Why can't you stop?

It might be thought (and it is in some quarters) that a simple, powered continuous braking system is as good as the slightly more complicated automatic one. The trouble is, if the simple system goes wrong (very easy, a tiny drop of condensation or dirt in the ejector cone will do it - very possible) you are brakeless, and you don't know it until too late! Also of course when pulling children, little fingers can get where you don't want 'em to; uncoupling of pipework is not precisely unknown.

With the automatic system, if the ejector does go on strike during a run, the brakes go on anyway; recollect that the railwayman's prime directive is 'fail safe'. If you can't pull up a vacuum before you start, then you won't start! The same applies to the automatic air brake.

Lillian

A point that I missed in an earlier construction article concerns the necessary clearance 'twixt wheel hub and inner side of coupling rods. There are unlikely to be any great forces involved, but a certain law of nature says that these two bits will inevitably rub together. Result - exit any paint off wheel hubs and peculiar patterns appearing on said wheel hub. The inside of the coupling rods is not normally visible to the onlooker, and is not normally painted anyway. Although, as this is not a scale copy of any given prototype this matter is up to the builder. A thin washer is all that is required as a spacer; I am using some 20 gauge brass for this. A thicker washer or spacer will be a boon between coupling and connecting rods - see drawing.

There is not much point in me giving exact measurements for this, for there are quite a number of variables concerned and the thickness is best left to 'final tuning-up' before finishing. It will probably be about 1/4in. so as to allow the centre driving wheel's crankpin retaining nut to clear the connecting rod and to bring the connecting rod into alighment with the cylinder centres. Another thin washer might well be used between return crank and connecting rod on the drive centre's crankpin; however a certain amount of side clearance here is not a handicap.

Incidentally, some needle roller bearings have an oil-hole in the outer case but some do not.

For the first case, when you press or bond in the race, ensure that this hole matches up roughly with the oil-hole in the rod(s) concerned, in the other case file or chip a small groove in the bore of the rod so that oil shoved in at the top can get out sideways onto the crankpin. Best for any such grooves to be towards the inside of the engine. It will find its own way into the bearing.

Do not on any account try to drill an oil hole in the bearing if there isn't one, for the outside of the race is very hard indeed and your drills will just bounce off and/or break.

Problem

An unfortunate combination of circumstances means that, for a while, my writings will not be too much on the construction of *Lillian*. I am slowly recovering from my recent operation, perhaps best described as 'a re-bore of lower portion of spine'. Tricky. Operation successful, recovery not over-fast; for I still have to hobble around with sometimes two sticks, workshop use is spasmodic to say the least. Added to that is the fact that we have to sell our house and move to a bungalow - 'one of those things sent to try us'. Still, what can't be cured must be endured, and perhaps needless to state I will do my best.

I was intrigued by David Bennett's letter in *M.E.* 4278, 21 July 2006 re the matter of sharp cutters. I recall handling a newly-sharpened 2in. diameter end mill; it slipped neatly through my fingers cutting quite deeply. It is a surprising, almost unbelievable, fact that skin is nearly impossible to cut by direct right-angle pressure, a slicing action is needed.

That is why circus performers can walk on sharp edge-up swords. Now, I strongly advise anyone wanting to try this to be of the greatest care, for errors would be very nasty. It is possible to grip a brand-new double-edged razor blade between thumb and fingers (sharp edges against skin) and break it by crushing it until it snaps under the pressure, leaving no visible marks on the skin. Make quite certain that the cutting edges are near-as-possible at right angles to the skin - very important. I have done it many times for demonstration purposes only (no point in mere trickery) for it is worth remembering that if for any reason you must handle any sharp tools - plain cutting edges, *not* sharp points - then a firm grip is best. Trouble is if the pesky tool does slip, then you are up a certain creek without a paddle. Thick gloves can help, but the possible slicing action must be avoided. You are not likely to hurt a milling cutter by using 'engineer's pliers', even if used on the cutting edges.

The photographs shew the fork-joint pivot and C-nut assembly on the centre wheels, and the view of the spacers on the main drive centre crankpin. The locking taper pins are not fitted so far.

●*To be continued.*

CLUB CHAT

With Malcolm Stride

UK News

The use of a mechanical digger made life easy when new power cables were laid at **Bournemouth DSME** earlier in the year. The report comments, *"As quick as the trench was dug, the cable was laid and partly back filled"*. The digger even pushed a scaffold pole to take the cable under the footpath which made light work of what could have been a difficult job.

Bradford MES had a stand at the Harrogate exhibition with Michael Gray's *Britannia* and David Brimacombe's 4F both attracting a lot of attention. Progress is being made on the planned boating pond with a proposal to extract water from the beck to feed the pond being looked into.

The revised signalling arrangements on the raised track at the Ashton Court site of **Bristol SMEE** are now complete and in operation. A new signal box *Ashton Junction* is nearing completion and will be installed. Eric Lindsay is putting the finishing touches to the club 3in. scale Fowler traction engine which will soon be available for members to use. Volunteers are being sought to look after the engine and *"champion its use by members"*.

East Somerset SMEE had a very successful running session at the Bath and West Show this year with 5,283 passengers being carried during the event. The event saw all the locomotives and rolling stock pressed into service in order to keep up with the demand for rides. The other good news is that the society has signed the lease on its facilities and now has a home assured until 2029. Membership is also increasing with a net gain of four members recently.

Work on *Wilde Memorial*, a 60 year-old locomotive at **Edinburgh SME** has been taking place with the locomotive being given *"a complete make over"*. This includes the locomotives third boiler and a new regulator. The cylinders have also been re-lined and the valve gear has had an overhaul. The society also had a stand at the Harrogate Exhibition this year. Member Norman Clasper gained second prize in the locomotive section for his A3 locomotive *Hyperion*.

We have received news of a merger between two societies in Dorset. **Ferndown Model Engineers** has merged with another local group, **Big Boys Toys**. The merger will benefit both groups and hopefully encourage more new members to join the larger and more viable group. Activities include slot car racing, radio control cars and lorries, 00 gauge railways, and $2^1/2$ and 5in. gauge live steam. The group meets monthly, normally on the third Saturday, at 2.00pm at the House of Destiny Christian Centre, 25A Elliott Road, West Howe, Bournemouth BH11 8LQ. Further information can be obtained from Secretary Ray Gardiner on 0781-407-2041 and anyone wishing to attend should contact Ray in advance to confirm the date of the meeting. We wish the new group much success and look forward to reporting its activities in the future.

The **Guildford MES** 16mm portable track was taken to the Old Kiln Museum at Tilford in April and the visit was a test of the new extensions constructed during the winter. The extensions have given much more room in the centre for the operators and proved a great success. This was followed by an outing to the Merstham Show in May where a continuous display was put on for the visitors. Three boiler tests were carried out at the show due to members buying locomotives at the 16mm Association stand and wanting to run them at the show. John Day comments about using the chuck upright on the rotary table and the problems that occur when the small piece of work is dropped and falls through the chuck and into the T-slot on the milling table, necessitating removal of the rotary table to retrieve it. John's solution is *"a number two Morse taper cork"* for the chuck adaptor. Alan Jensen has discovered that his Manor locomotive is fitted with a rain gauge. After a very wet day public running, Alan discovered that the fireman's bucket was nearly half full. He is thinking of calibrating the bucket so that he will know when to come off the track!

Hereford SME has banned photography on moving trains for safety reasons. Wally Sykes has commissioned his new 0-6-0 Dockyard diesel locomotive *Ann of Ross*. The locomotive is powered by a 5hp Honda engine via a hydraulic gearbox and timing belts. Wally did not work from drawings and writes that *"the only measurements I needed were the $7^1/4$in. gauge and the radius of the track at its tightest*

CLUB DIARY

A minimum of 6 weeks notice is required for diary entries. Clubs and Societies are asked to include a telephone number for the assistance of would-be visitors.

SEPTEMBER

1 **Aylesbury (Vale of) MES.** *Track Night.* Contact Andy Rapley: 01296-420750.
1-3 **Bedford MES.** *Rally Weekend.* Contact Ted Jolliffe: 01234-327791.
1 **Canvey R&MEC.** *Seen on the Table 3.* Contact Brian Baker: 01702-512752.
1 **Maidstone MES (UK).** *Evening Run and Fish 'n' Chips.* Contact Martin Parham: 01622-630298.
1 **North London SME.** *Work in Progress.* Contact David Harris: 01707-326518.
1 **North Norfolk MEC.** *Bits & Pieces.* Contact Gordon Ford: 01263-512350.
1 **Portsmouth MES.** *Dave Parsons: Sterling Engines.* Contact John Warren: 023-9259-5354.
1 **Rochdale SMEE.** *FAJ Collin: Building a Class 40.* Contact Mike Foster: 01706-360849.
1 **Romford MEC.** *Competition Night.* Contact Colin Hunt: 01708-709302.
2 **Cardiff MES.** *Steam-Up and Family Day.* Contact Don Norman: 01656-784530.
2/3 **Chesterfield MES.** *Open Weekend.* Contact Mike Rhodes: 01623-648676.
2/3 **Dockland & E. London MES.** *Public Running.* Contact P. M. Jonas: 01708-228510.
2 **High Wycombe MEC.** *Family Day.* Contact Eric Stevens: 01494-438761.
2 **Ickenham DSME.** *Public Running.* Contact David Sexton: 01895-630125.
2 **Isle of Wight MES.** *Track & Pond.* Contact Malcolm Hollyman: 01983-564568.
2 **Malden DSME.** *Families Day.* Contact John Mottram: 01483-473786.
2 **New Jersey Live Steamers, Inc.** *Work Day.* Contact Karl Pickles: 718-494-7263.
2/3 **Romney, Hythe & Dymchurch Railway.** *A Day Out With Thomas.* Information: 01797-362353.
2 **SM&EE.** *Gordon Hatherill & Peter Trinder: An Intro. to Gauge 1 Modelling.* Contact David Boote: 01202-745862.
2 **South Lakeland MES.** *Open Day and 10th Anniversary Celebration.* Contact Adrian Dixon: 01229-869915.
2 **Sunderland (City of) MES.** *Meeting.* Contact Albert Stephenson: 01429-299649.
2/3 **Tyneside SMEE.** *Autumn Rally.* Contact Malcolm Halliday: 0191-2624141.
2/3 **Guild of Model Wheelwrights.** *Chatsworth Country Fair, Bakewell, Derbyshire.* Contact Biddy Hepper: 01492-623274.
2 **York City & DSME.** *Summer Meeting.* Contact Pat Martindale: 01262-676291.
3 **Ellenroad Engine House.** *Rochdale Photographic Society & Display of Vintage Cameras.* Enquiries: 01706-881952.
3 **Frimley & Ascot LC.** *Public Running.* Contact Bob Dowman: 01252-835042.
3 **Guildford MES.** *Members' Running Day.* Contact Dave Longhurst: 01428-605424.
3 **Malden DSME.** *Public Running.* Contact John Mottram: 01483-473786.
3 **Northampton SME.** *Public Running.* Contact Pete Jarman: 01234-708501 (eve).
3 **Nottingham SMEE.** *Public Running.* Contact Gerry Chester: 0115-9259096.
3 **Pinewood MRS.** *Members' Steam-Up.* Contact Ivan Hurst: 01252-510340.
3 **Plymouth MSLS.** *Public Running.* Contact John Brooker: 01752-671722.
3 **Rugeley Power Station MES.** *Annual Open Day.* Contact Dereck Moore: 01543-490023.
3 **Sunderland (City of) MES.** *LBSC Memorial Bowl Competition.* Contact Albert Stephenson: 01429-299649.
4 **New Jersey Live Steamers, Inc.** *Labor Day Run.* Contact Karl Pickles: 718-494-7263.
4 **Peterborough SME.** *Bits & Pieces.* Contact Ted Smith: 01775-640719.
5 **Stamford MES.** *Talk: Traction Engine Construction.* Contact Derek Brown: 01780-753162.
5 **Taunton ME.** *Brains Trust.* Contact Don Martin: 01460-63162.
6 **Bradford MES.** *Meeting.* Contact John Mills: 01943-467844.
6 **Bristol SMEE.** *John Burgoyne: Building a Scale Model Monitor Agricultural Engine.* Contact Trevor Chambers: 0145-441-5085.
6 **Leeds SMEE.** *Meeting.* Contact Colin Abrey: 01132-649630.
6 **West Wiltshire SME.** *Steam-Up.* Contact R. Nev. Boulton: 01380-828101.
7 **South Lakeland MES.** *Meeting.* Contact Adrian Dixon: 01229-869915.
7 **Sutton MEC.** *Bits & Pieces.* Contact Bob Wood: 0208-641-6258.
9/10 **Birmingham SME.** *17th National Locomotive Rally.* Contact John Walker: 01789-266-065.
9/10 **Isle of Wight MES.** *Bi-Annual Exhibition with Steam Boats at Riverside.* Contact Malcolm Hollyman: 01983-564568.
9/10 **Leighton Buzzard NG Rly.** *Steam-Up Weekend.* Enquiries: 01525-373888.
9 **Leyland SME.** *Running in the Dark plus Fish & Chip Supper.* Contact A. P. Bibby: 01254-812049.
9 **Sunderland (City of) MES.** *Meeting.* Contact Albert Stephenson: 01429-299649.
10 **Bristol SMEE.** *Public Running.* Contact Trevor Chambers: 0145-441-5085.
10 **Cambridge MES.** *Public Running.* Fulbrooke Road. Contact Rex Mountfield: 01284-386128.
10 **Canterbury DMES (UK).** *Public Running.* Contact Mrs P. Barker: 01227-273357.
10 **Edinburgh SME.** *Track Running Day Steam & Diesel.* Contact Robert McLucke: 01506-655270.
10 **Guildford MES.** *Driver Training.* Contact Dave Longhurst: 01428-605424.

In Memoriam

It is with the deepest regret that we record the passing of the following members of model engineering societies. The sympathy of staff at *Model Engineer* is extended to the family and friends they leave behind.

Alan Harmer	*North London SME*
Philip John Holden	*Society of Ornamental Turners*
David Timson	*Hereford SME*

bend". Wally did do a mock-up of the chassis to check the location of the various components before cutting metal. The locomotive ran well all day and was driven by other members as well as Wally. The newsletter also carries some information from Richard Donovan about an unusual V-twin-engined railcar in Tasmania. The railcar is powered by a 2-litre Riley V-twin engine of the same type that powered the Riley 12/18 car of the era and is now restored at the Don River Railway, Devonport, Tasmania.

The Bits & Pieces evening at **Northampton SME** has fallen foul of its own success, with so many items brought to show, that it was difficult to see the various exhibits. The opinions of members are being sought on proposals for changes to the track facilities and future site development.

Progress is being made on extensions to the track on the new land at **North London SME** with the railway development group having marked out the proposed extension of the main line as well as the first phase of the ground level railway.

At the May public running day, Dave Tompkins from the **Staines SME** gave his new electric 125 locomotive its first test run following completion. The locomotive ran well and proved very controllable. Stan Bishop is currently working on a history of the society using the records dating back to 1945 and is looking for pictures to illustrate the document. I am sure Stan would be pleased to hear from any readers who have pictures taken at society events.

Joe Dobson from the **Stamford MES** used a domestic steam cleaner to remove the accumulated oil and grease from his locomotive followed by degreasing with a solvent prior to repainting with an acrylic automotive spray called Hycote. Joe reports that this covers well and will be finished of with a polyurethane varnish to give a hard protective coating. During the steam cleaning process, *"the garage resembled a sauna"*, according to Joe's report.

John Cook reports that in spite of several competing events including the Surrey County Show at Guildford and the 'Green Fair' in Kingston Market the Spring Bank Holiday running at the Leatherhead track of **Surrey SME** had plenty of visitors. Old favourites *Helen Claire* and *Queen of Carolina* headed the steam list and a petrol hydraulic locomotive completed the $7^1/4$in. gauge line up. The 5in. locomotives were a class 37 and a class 40 coupled together (both battery operated) hauling a rake of coaches filled with passengers but the locomotive which captured everyone's imagination was a tiny battery powered 0-4-0 diesel shunter a mere $23^1/2$in. long and hauling three passengers at a time round the circuit. On the raised track, *Helen,* a 5in. gauge 0-6-0 Great Western Pannier tank locomotive was taking passengers for a ride as well.

I recently included some workshop definitions from the **Sutton MEC** and include some more this time;

Electric Hand Drill – Normally used for spinning pop rivets in their holes but also handy for drilling holes in the wrong place.

Pliers – Used to round off bolt heads.

Hacksaw – One of a family of cutting tools built on the Ouija board principle. It transforms human energy into a crooked unpredictable motion, and the more you attempt to influence its course, the more dismal your future becomes.

Thanks to the efforts of Don Bowerman, a group of members from **York City DSME** had an interesting visit to the stonemasons yard at York Minster. The group saw the large stone cutting saw in action, making short work of cutting through a two tonne stone block. Every stone that is replaced in the Minster is accurately drawn and catalogued on a computer database. The very skilled work carried out by the stonemasons was much admired by the visitors.

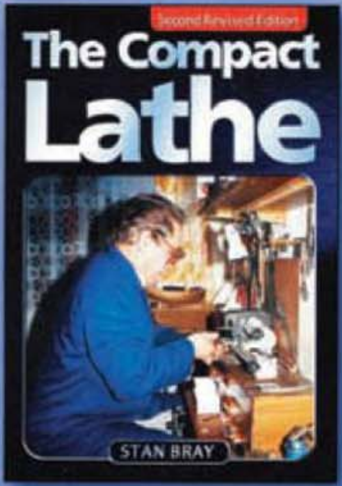
World News

Australia

The brickwork for the new signal box is now complete at **Hornsby Model Engineers** and work has started on the erection of the timber framing. A weather proof CCTV camera has been mounted near the Dainton Bank, not to deter vandals but to aid the signalling staff in controlling the traffic at times when there is a build up of trains in the station. The anniversary display will be held over the weekend of 7/8 October this year and members are being asked to provide models for display.

10	**Harlington LS.** *Exhibition Day.* Contact Peter Tarrant: 01895-851168.
10	**High Wycombe MEC.** *Club Running afternoon.* Contact Eric Stevens: 01494-438761.
10	**Hornsby ME.** *Running Day.* Contact Ted Gray: 9484-7583.
10	**Leeds SMEE.** *Running Day.* Contact Colin Abrey: 01132-649630.
10	**Northern Mill Engine Society.** *Open Day.* Contact John Phillip: 01257-265003.
10	**Nottingham SMEE.** *Public Running.* Contact Gerry Chester: 0115-9259096.
10	**Plymouth MSLS.** *Members' Running Day.* Contact John Brooker: 01752-671722.
10	**Stephenson Memorial Miniature Locomotive Ass'n.** *Annual Efficiency Trial hosted by West Cumbria Guild of Model Engineers, Curwen Park, Workingtom – entries from member clubs only.* Contact Eddie Gibbons: 0191-4107564.
10	**Surrey SME.** *Public Running.* Contact John Cook: 020-8397-3932.
10	**Worthing DSME.** *Public Running.* Contact Bob Phillips: 01903-243018.
10	**York City & DSME.** *Running Day.* Contact Pat Martindale: 01262-676291.
11	**Bedford MES.** *A home-made CNC machine.* Contact Ted Jolliffe: 01234-327791.
11	**Saffron Walden DSME.** *Club Night.* Contact Jack Setterfield: 01843-596822.
12	**Dockland & E. London MES.** *Meeting.* Contact P. M. Jonas: 01708-228510.
12	**Romney Marsh MES.** *Track Meeting.* Contact John Wimble: 01797-362295.
12	**Sutton MEC.** *Track Day.* Contact Bob Wood: 0208-641-6258.
13	**Chingford DMEC.** *Derek Brown: Designing a Loco using CAD.* Contact Ron Manning: 020-8360-6144.
13	**Hull DSME.** *Malcolm Foster & Paul Varey: Sheet Metalwork 2- Pattern Development.* Contact Tony Finn: 01482-898434.
13	**Pinewood MRS.** *Members' Steam-Up.* Contact Ivan Hurst: 01252-510340.
13	**St. Albans DMES.** *Michael Joseph: Irish Railways 1978.* Contact Roy Verden: 01923-220590.
13	**Stockholes Farm MR.** *Members' Evening Running.* Contact Ivan Smith: 01427-872723.
14	**Leyland SME.** *Project Night.* Contact A. P. Bibby: 01254-812049.
14	**Sutton MEC.** *Gauge 1 Round-Up.* Contact Bob Wood: 0208-641-6258.
14	**Worthing DSME.** *John Brierly: '0' Gauge Techniques.* Contact Bob Phillips: 01903-243018.
15	**Canvey R&MEC.** *Meeting.* Contact Brian Baker: 01702-512752.
15	**North London SME.** *Where do we go from here?* Contact David Harris: 01707-326518.
15	**Rochdale SMEE.** *Video Night.* Contact Mike Foster: 01706-360849.
15	**Romford MEC.** *Peter Lawrence: Villages of East London.* Contact Colin Hunt: 01708-709302.
15/16	**Guild of Model Wheelwrights.** *Northern Model Engineer & Modelling Exhibition, Pickering Arena.* Contact Biddy Hepper: 01492-623274.
16	**Brighton & Hove SMLE.** *Fun Run.* Contact Mick Funnell: 01323-892042.
16	**Canvey R&MEC.** *Members' Running Day.* Contact Brian Baker: 01702-512752.
16/17	**Claymills Pumping Engines.** *Open Days.* Contact B. Eastough: 01283-812501.
16	**Hereford SME.** *Club Day.* Contact Nigel Linwood: 01432-270867.
16	**North Norfolk MEC.** *1940s Weekend.* Contact Gordon Ford: 01263-512350.
16/17	**Papplewick Pumping Station.** *Steaming Days.* Enquiries: 0115-963-2938.
17	**Bedford MES.** *Public Running.* Contact Ted Jolliffe: 01234-327791.
17	**Bristol SMEE.** *Public Running.* Contact Trevor Chambers: 0145-441-5085.
17	**Frimley & Ascot LC.** *Club Running.* Contact Bob Dowman: 01252-835042.
17	**Guildford MES.** *Charity Day.* Contact Dave Longhurst: 01428-605424.
17	**Pinewood MRS.** *Public Running.* Contact Ivan Hurst: 01252-510340.
17	**Plymouth MSLS.** *Public Running.* Contact John Brooker: 01752-671722.
17	**Romney Marsh MES.** *Autumn Track Meeting.* Contact John Wimble: 01797-362295.
17	**Rugby MES.** *Public Running.* Contact David Eadon: 01788-576956.
17	**Saffron Walden DSME.** *Running Day (public running after 2pm).* Contact Jack Setterfield: 01843-596822.
17	**St. Albans DMES.** *Puffing Field Morning.* Contact Roy Verden: 01923-220590.
18	**Cardiff MES.** *Visit by Brean Sands Modellers.* Contact Don Norman: 01656-784530.
18	**Model Steam Road Vehicle Soc.** *Modellers' Question Time.* Contact Geoff Miles: 01869-247602.
18	**Peterborough SME.** *Norman Smedley: 150 years of Foden.* Contact Ted Smith: 01775-640719.
19	**Chesterfield MES.** *Stephen Gay: Dukeries Route Railway.* Contact Mike Rhodes: 01623-648676.
19	**Nottingham SMEE.** *Mervyn Allcock: Saving a Round House.* Contact Graham Davenport: 0115-8496703.
19	**Romney Marsh MES.** *Track Meeting.* Contact John Wimble: 01797-362295.
19	**Taunton ME.** *Trophy Night.* Contact Don Martin: 01460-63162.
20	**Bournemouth DSME.** *Dick Ganderton: Railway Wheels & Track.* Contact Dave Fynn: 01202-474599.
20	**Bristol SMEE.** *Bring & Buy.* Contact Trevor Chambers: 0145-441-5085.
20	**Chingford DMEC.** *Ron Walker: The Welsh Highland Railway.* Contact Ron Manning: 020-8360-6144.
20	**Guildford MES.** *Bits & Pieces.* Contact Dave Longhurst: 01428-605424.
20	**Leeds SMEE.** *Meeting.* Contact Colin Abrey: 01132-649630.
20	**Maidstone MES (UK).** *Members' Playtime Run.* Contact Martin Parham: 01622-630298.
20	**MELSA.** *Meeting.* Contact Graham Chadbone: 07-4121-4341.
20	**West Wiltshire SME.** *Steam-Up.* Contact R. Nev. Boulton: 01380-828101.
21	**East Somerset SMEE.** *Steam-Up.* Contact Roger Davis: 01749-677195.
21	**Sutton MEC.** *Derek Tidbury: Brunel's Great Eastern.* Contact Bob Wood: 0208-641-6258.
22-24	**$7^1/4$in. Gauge Soc.** *AGM.* Contact John Nicholson: 01274-564215.
23	**Chesterfield MES.** *Public Running Day.* Contact Mike Rhodes: 01623-648676.
23	**Hornsby ME.** *Family Day & Boiler Inspection.* Contact Ted Gray: 9484-7583.
23	**Maxitrak Owners Club.** *Factory Open Day & MOC AGM.* Contact Eric Penn 0208-979-4335.
23	**Rugby MES.** *Night Steam-Up.* Contact David Eadon: 01788-576956.
23	**Welling DMES.** *Open Day.* Contact Reg Hawes: 0208-859-1952.
24	**Amnerfield Miniature Railway.** *Public Running.* Contact David Jerome: 0118-9700274.

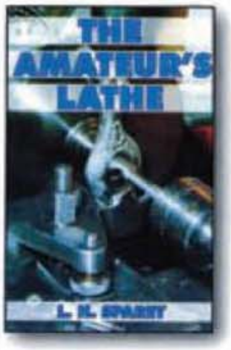
Compact Lathe
Second Revised Edition
Stan Bray



The evolution of the compact, or portable, lathe has bought many a model engineer's life-long ambition to reality. This comprehensive introduction to the subject covers the very latest technology, the machine operations and facilities which will enable the novice or experienced operator to achieve the highest standards of lathe work.

- 2004
- 978 185486 227 3
- 210 x 147mm
- 187 pages
- 145 b&w photographs
- Paperback
- £8.95

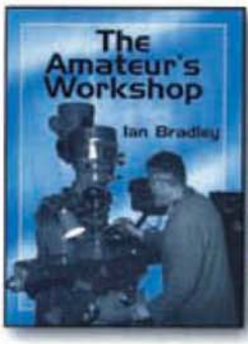
The Amateur's Lathe
L.H. Sparey



- 1972
- 978 085242 288 5
- 216 x 138mm
- 224 pages
- Illustrated paperback
- £8.95

First published in 1948, this is the classic, definitive work on the use of the small (3½ inch) lathe which has proved invaluable to generations of light engineers, small garage owners and precision ahobbyists, apprentices and engineering professionals alike.

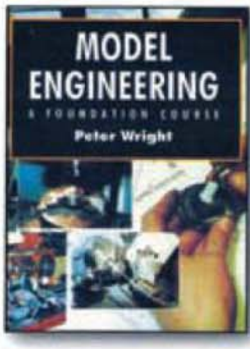
The Amateur's Workshop
Ian Bradley



- 1995
- 978 185486 130 6
- 210 x148mm
- 256 pages
- Illustrated paperback
- £8.95

All model engineers are occasionally faced with an operation outside their usual experience. With more than 430 line and photographic illustrations, this is a comprehensive reference book providing information on setting up a workshop and the use of various machines and tools. Processes such as knurling, reaming, milling etc. are also covered.

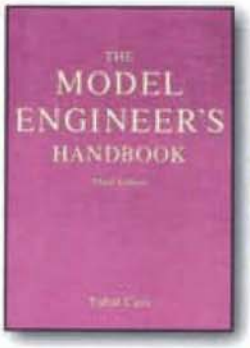
Model Engineering – A Foundation Course
Peter Wright



- 1997
- 978 185486 152 8
- 236 x 189mm
- 416 pages
- Illustrated paperback
- £16.95

A text book by an experienced model engineer covering all the basic techniques: understanding engineering drawings, buying materials and marking out, sawing, filing, bending and forming metals. Includes a review of engineering materials, and the making of cutting tools in the home workshop for practical people who have little experience of working in metal.

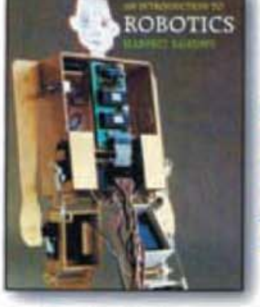
Model Engineer's Handbook
Third Edition
Tubal Cain



- Third Edition
- 1996
- 978 185486 134 4
- 210 x 148mm
- 240 pages
- Illustrated paperback
- £9.95

This third edition comprises a compilation of tables, facts, procedures and data that the author has found invaluable in his model engineering activities including the use of data and calculations in both imperial and SI units. The book also contains helpful explanations of the hows and whys of using many of the entries.

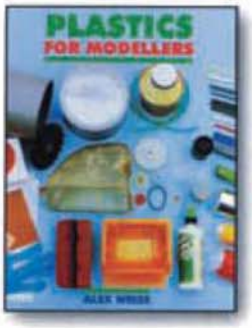
An Introduction to Robotics
Harpit Sandhu



- 1997
- 978 185486 153 5
- 236 x189mm
- 208 pages
- Illustrated paperback
- £9.95

An introduction for the amateur to the ideas and concepts of robotics. The first part explains how and why robots work and are controlled, while the second part shows you how to make a simple two-legged humanoid robot that can be programmed to walk. Everything is presented in clear, concise everyday English. The robot can be built on your kitchen table and can be run from a personal computer.

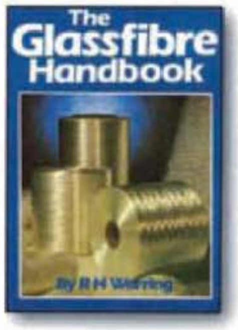
Plastics for Modellers
Alex Weis



- 1998
- 978 185486 170 2
- 236 x189mm
- 160 pages
- Illustrated paperback
- £7.95

This book, for the first time, provides a comprehensive guide to the use of plastics in the many and varied fields of modelling. Various types and forms of plastics are described and their useful characteristics, strengths and weaknesses are detailed. Well illustrated with informative line drawings, instructive photographs and amusing cartoons, it explains why you might choose, plastics over the more commonly used materials such as wood and metal.

The Glassfibre Handbook
R.H.Warring

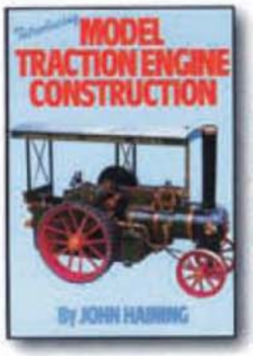


- 1989
- 978 085242 820 7
- 210 x 148mm
- 160 pages
- Illustrated paperback
- £8.95

A prime reference book on glassfibre materials and techniques Includes information on methods and materials, and covers models, boats, cars and all types of grp work.

ORDER HOTLINE:

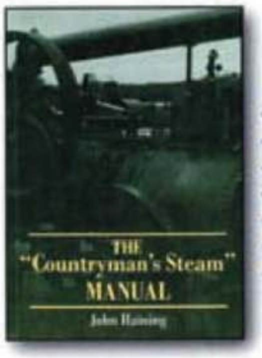
Introducing Model Traction Engine Construction
John Haining



1983
978 085242 805 4
210 x 148mm
112 pages
Illustrated paperback
£6.95

The doyen of traction engine modelling explains and illustrates what is involved in the construction of working steam models (including workshop processes and tools needed) and outlines the history and variety of suchengines.

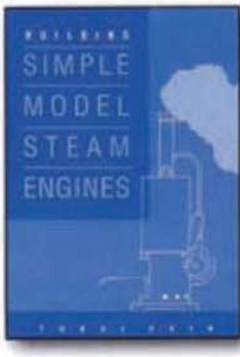
The Countryman's Steam Manual
John Haining



1996
978 185486 136 8
210 x148mm
96 pages
Illustrated paperback
£5.95

First published in 1982, this new and enlarged edition covers the design, construction and care of steel boilers in general, with formulae and data used by firms of repute. Designs of three vertical boilers are included - the Sentinel, the Caradoc and a 3-inch scale version.

Building Simple Model Steam Engines
Tubal Cain



1993
978 185486 104 7
210 x148mm
112 pages
Illustrated paperback
£5.95

The sheer simplicity of miniature oscillating steam engines has an enduring fascination for all marine and model engineers. This book shows how to build four model steam engines and features designs and plans that even a beginner will be able to follow.

Building Simple Model Steam Engines 2
Tubal Cain

1997
978 185486 147 4
210 x148mm
112 pages
Illustrated paperback
£5.95

Since the publication of the first book, the author has designed and built several more engines ranging from a delightful little turbine to a larger engine in the style of the magnificent 'Steam Engines of the Highest Class' offered by toymakers before WW1. Fully detailed methods of construction with the beginner in mind.

Early British Quick Firing Artillery
Len Trawin

1988, 978 185486 154 2, 189 x 246mm,
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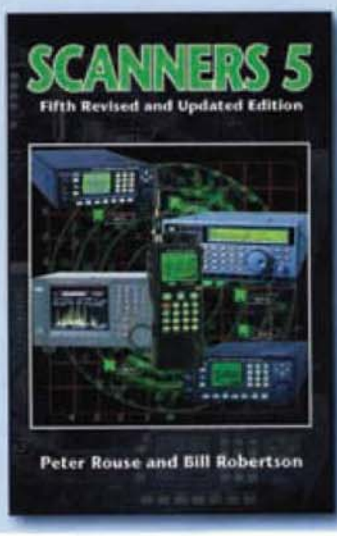

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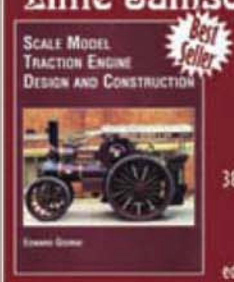

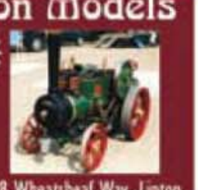

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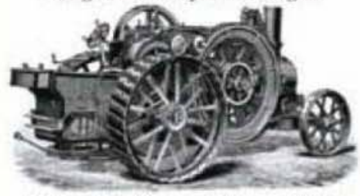

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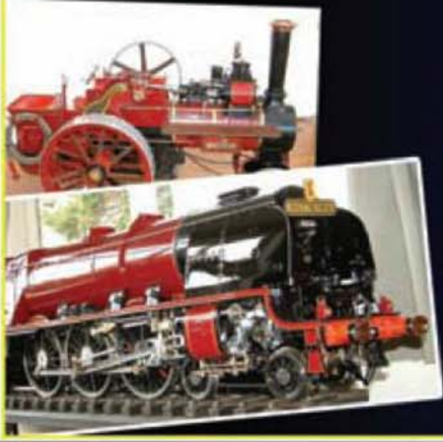

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